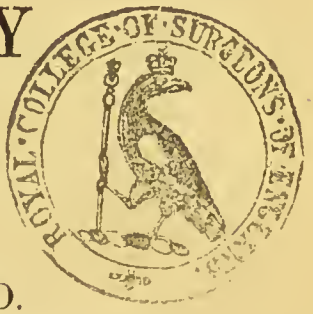
A HANDBOOK

OF

MEDICAL AND SURGICAL ELECTRICITY





BY

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LATE MEDICAL OFFICER FOR ELECTRICAL TREATMENT TO THE HOSPITAL FOR SICK CHILDREN GREAT ORMOND STREET, ETC. ETC.

SECOND EDITION, REVISED AND ENLARGED

WITH NINETY-FIVE ILLUSTRATIONS

LONDON
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1877

TO

The Memory of the late

Dr. G. B. DUCHENNE (de Boulogne),

Lauréat de l'Institut de France et de l'Académie de Médecine,
Chevalier de la Légion d'honneur, &c. &c.,

"THE FATHER OF ELECTRO-THERAPEUTICS,"

This Handbook is Dedicated

BY ITS AUTHOR,

AS A TRIBUTE OF RESPECT AND ADMIRATION,

FOR ONE TO WHOM PHYSIOLOGY AND PATHOLOGY ARE ALIKE INDEBTED,

NOT ALONE FOR NEW DISCOVERIES,

BUT FOR THE RECTIFICATION OF LONG-STANDING ERRORS;

AND WHOSE LIFE WAS DEVOTED WITH RARE EARNESTNESS AND SINGLENESS

OF PURPOSE TO THE APPLICATIONS OF ELECTRICITY

IN THE INVESTIGATION AND ALLEVIATION OF DISEASE.

PREFACE

TO

THE SECOND EDITION.

The demand for a Second Edition of this book, both in England and in America, has encouraged me to devote to its improvement all the time and labour that could be spared from other and more onerous duties. While every page has been subjected to the most careful revision—and it is hoped that nothing of any real importance has been unnoticed, and that the work has been brought to the level of our present experience—it has not been allowed to extend to unmanageable dimensions, but the endeavour has been made to keep it a handy yet complete digest of the *essentials* of medical and surgical electricity. Thirty-one new illustrations have been added, and some of the older ones have been redrawn. Since the publication of the first edition other text-books upon medical electricity have issued from the press, showing that the study of electro-therapeutics has increased, and that there is a more general diffusion

of the knowledge of a branch of medicine which for too long a time was neglected by the medical profession. It will always be a source of gratification to me to feel that I was enabled to contribute in some degree to this result.

CAVENDISH SQUARE, W.
April, 1877.

PREFACE

TO

THE FIRST EDITION.

I SHOULD hesitate to add to the multitude of treatises upon medical electricity which are before the profession did I know of any which, avoiding contested points in electro-physiology and therapeutics, teach the busy practitioner not only when to use electricity, but, *in explicit and full detail*, how; and which in moderate bulk contain only what it is essential to master. For a book of this sort I believe there is a general want, and that want I have endeavoured to supply. I claim no originality. There will be found here no new ground opened out, but only an earnest endeavour to sift the wheat of our existing knowledge from the chaff, and to make the reader as much at home with his electrical as with his other medical instruments; and further to lead him to estimate electricity at its fair and proved value in therapeutics, as an agent, not to be indiscriminately advocated as a panacea, nor, on the other hand, neglected by the

inexperienced, but in appropriate cases to be regarded as one of the most powerful and serviceable weapons with which we can combat disease. A handbook such as this should seek to give the results of the best work; and in endeavouring to carry this conception into execution I have availed myself freely of the extended experience of the Electrical Room of the National Hospital for the Paralysed and Epileptic, and have carefully consulted the standard authorities, especially Duchenne's unrivalled and exhaustive treatise on "Localized Electrization." For much of the anatomical detail in indirect electrization I am indebted to Ziemssen's "Die Electricität in der Medizin;" and of the illustrations some are original, and others are taken from Duchenne and Ziemssen.

I have throughout endeavoured to keep constantly in view the practitioner rather than the theorist, especially in those points of detail which are of importance in order to secure the successful application of electricity, and to insure (a not insignificant matter in this respect) the comfort of the patient.

The instruments described are those which for some years I have made use of as well in private as in hospital practice, and they are equally adapted for either.

H. T.

January 27th, 1873.

CONTENTS.

PAGE

Preface to the Second Edition vii
„ First Edition ix

CHAPTER I.

ELECTRICITY AND ELECTRO-MEDICAL INSTRUMENTS.

General Remarks on Electro-Therapeutics . . . 1
„ „ Nomenclature 3
„ „ Instruments 4
The Different Varieties of Electricity 3
1. *Franklinism* 4
„ Method of Generating 4
„ The Plate Machine 4
„ Accessories required 6
„ Winter's Machine 7
2. *Voltaism* 7
„ The Essentials of a Voltaic Battery . . 8
„ The Becker-Muirhead Battery . . . 9
„ The Tibbits Voltaic Battery . . . 16
„ Foveaux's Portable Battery . . . 21
„ Stöhrer's Battery 24
„ Pulvermacher's Chain Battery . . . 28
3. *Faradism* 30
„ The Essentials of a Faradic Instrument . 30
„ The Tibbits Faradic Battery . . . 30
„ Duchenne's Large Volta-Faradic Instrument 36
„ „ Uncovered „ „ . 38
„ „ Small „ „ . 43
„ „ Magneto-Faradic „ . 46

PAGE

Faradism, continued—

„ Stöhrer's Large Volta-Faradic Instrument . 53
„ „ Small Volta-Faradic „ . 52
„ The Tibbits Combined Hospital Battery . 55
„ The Tibbits Combined Portable Battery . 57
The Accessories of Electrical Apparatus . . . 59

CHAPTER II.

THE APPLICATION OF ELECTRICITY.

General Considerations 60
Historical Notice 60
Localized Electrization 61
„ „ Its Varieties 61
Franklinization 62
„ Its Administration 62
„ „ (*a*) Electro-Positive Bath 62
„ „ (*b*) Electro-Negative Bath 63
„ „ (*c*) by Sparks . . 63
„ „ (*d*) by Leyden Jar . . 63
Voltaization 64
„ The Constant Current 64
„ The Interrupted Voltaic Current . . . 65
„ The Positive Charge 65
Localized Voltaization and Localized Faradization . . 66
Direct Muscular Electrization 66
Indirect „ „ 71
„ „ „ (*a*) of the Head . 73
„ „ „ (*b*) of the Neck . 78
„ „ „ (*c*) of the Phrenic Nerves and their Accessories . 80
„ „ „ (*d*) of the Superior Extremity . 83
„ „ „ (*e*) of the Trunk . 90
„ „ „ (*f*) of the Inferior Extremity . 92
Electrization of Central Organs of Nervous System 98

PAGE

Cutaneous Faradization 99
(*a*) The Electric Hand 99
(*b*) Solid Metallic Rheophores . . . 99
(*c*) Metallic Thread 99
(*a*) Electric Cauterization . . 100
(*b*) „ Moxa 100
(*c*) „ Fustigation . . . 100
Electrization of Internal Organs 100
„ (*a*) of Rectum and Muscles of Anus . 100
„ (*b*) of Bladder 100
„ (*c*) of Uterus 102
„ (*d*) of Larynx 102
„ (*e*) of Male Genitals 103
Electrization of the Organs of the Senses . . 104
„ (*a*) of Retina 105
„ (*b*) of Auditory Nerve . . . 105
„ (*c*) of Olfactory Nerves . . . 105
„ (*d*) of Nerves of Taste . . . 105

CHAPTER III.

ELECTRICITY AS AN AID TO DIAGNOSIS.

Limitation of Electricity in Diagnosis 106
Method of Testing Farado-Contractility 106
„ „ Voltao-Contractility 107
Rule for Strength of Current 107
„ Direction „ 107
Diagnosis when Irritability is normal 108
„ „ „ diminished . . . 108
„ „ „ increased 108
„ „ „ diminished to Faradism and increased to Voltaism . 109
„ of Peripheral from Central Disease . . . 109
„ of Lead Palsy from Paralysis of Musculo-Spiral Nerve 110
„ of Real from Feigned Disease 112
Condition of Electro-Contractility in Paralysis from Disease of Brain 111

PAGE

Condition of Electro-Contractility in Paralysis from Disease of Spinal Cord . 111
,, ,, in Hysterical Paralysis . 111
,, ,, in Wasting Palsy . . 112
,, ,, in Essential Infantile Paralysis . . . 112
,, ,, as Proof Positive of Death . . . 112

CHAPTER IV.

ELECTRICITY IN MEDICINE.

General Considerations 114
Limitation of Electricity as a Remedy 114
Effects of Electricity upon Nutrition 114
,, ,, upon Secretion 115
Electrotonus 115
General Principles of all therapeutic applications of Electricity 117
Precautions to be observed in all Medical applications of Electricity 118
General Faradization 120
Centralized Galvanization 121
The Electrical Bath 122
Franklinization 124
,, (*a*) in Facial Neuralgia 125
,, (*b*) in Sciatica 126
,, (*c*) in Facial Spasm 126
,, (*d*) in Emotional Aphonia . . . 126
,, (*e*) in Hysterical Hyperæsthesia . . 127
,, (*f*) in Tremor 127
Voltaization 127
,, Dr. Radcliffe's "Positive Charge" . . 127
The Differential Use of Voltaization and Faradization . 130
Voltaization in Cerebral Disease 131
,, of "Sympathetic" (*so called*) . . . 131
,, of Cord 132
Voltaization in Neuralgia 132

PAGE

Faradization in Neuralgia 132
Franklinization ,, ... 132
Rules for the Application of Electricity in Paralysis . 139
,, when Irritability is normal 139
,, ,, ,, abolished 139
,, ,, ,, diminished 140
,, ,, ,, lessened or abolished to Faradism, but increased to Voltaism 140
,, in Atrophic Paralysis from Traumatic Lesion of Nerves 145
,, in "Essential" Infantile Paralysis 156
,, in Hemiplegia from Cerebral Disease . . . 170
,, ,, (*a*) when Muscles are lax . . 170
,, ,, (*b*) ,, ,, rigid . . 170
,, in Spinal Paralysis 176
,, in Progressive Muscular Atrophy 181
,, in Hysterical Paralysis 185
,, in Local Paralysis 187
(*a*) Lead Palsy 187
(*b*) Paralysis of Musculo-spiral Nerve . . 189
(*c*) Facial Paralysis 192
(*d*) Paralysis of Ocular Muscles . . . 197
,, in Amaurosis 198
,, in Deafness 200
,, in Glosso-labio-laryngeal Paralysis . . . 202
,, in Locomotor Ataxy 202
,, in Cases of Tremor 203
,, in Writers' Cramp 204
,, in Torticollis 204
,, in Athetosis 208
,, in Tonic Contraction of Muscles 210
,, in Reflex Contractions 212
,, in Diphtheritic Paralysis 213
,, in Affections of Bladder 214
,, in Incontinence of Urine in Children . . . 215
,, in Muscular Rheumatism 216
,, in Rheumatic Gout 217

PAGE
Rules for the Application of Electricity in Chloroform Narcosis 217
„ in Disorders of Cardiac Circulation . . . 218
„ in Functional Disorders of Innervation . . . 218
„ in Impotence 218
„ in Intussusception 220
„ in Epilepsy 220
„ in Insanity 221
„ in Diseases of the Skin 221

CHAPTER V.

ELECTRICITY IN SURGERY.

General Considerations 223
External Voltaization 223
Electrolysis 224
(*a*) in Nævi 225
(*b*) in Malignant Tumours 226
(*c*) in Aneurisms 230
The Galvanic Cautery 231
The Tibbits Galvano-Caustic Battery . . . 232

CHAPTER VI.

ELECTRICITY IN MIDWIFERY AND THE DISEASES OF WOMEN.

General Remarks 239
Importance of Care in Application 239
Rules for the Application of Electricity in Post-partum Hæmorrhage 240
„ in Inertia Uteri 241
„ in Abortion 241
„ for the Production of Premature Labour . . 242
„ in Miscarriages 242
„ in the Resuscitation of Still-born Children . . 243
„ as a Galactagogue 243
„ as an Emmenagogue 243
„ in Uterine Displacements 245
„ in Uterine Neuralgia 246
„ in Sterility 246
Concluding Remarks 246

LIST OF ILLUSTRATIONS.

		PAGE
1.	Plate Electrical Machine and Glass-legged Stool	5
2.	Winter's Electrical Machine	7
3.	Cell of Becker-Muirhead Battery	9
4.	Becker-Muirhead 100-cell Battery	10
5.	The Tibbits Voltaic Battery	16
6. 7.	Graduating Dials	19, 20
8. 9. 10.	Foveaux's Portable Voltaic Battery	22—24
11. 12.	Stöhrer's Voltaic Battery	25—27
13.	Pulvermacher's Band	29
14.	Pulvermacher's Chain	29
15.	The Tibbits Faradic Battery	31
16.	Diagram of Path of Current	33
17.	Disk and Lever	35
18.	Duchenne's Large Volta-Faradic Instrument	37
19. 20.	Duchenne's Large Uncovered Instrument	39
21.	Front View of the above	41
22. 23.	Duchenne's Small Volta-Faradic Instrument	43
24. 25. 26. 27.	Details of the above Instrument	44
28.	Duchenne's Magneto-Faradic Instrument	47

		PAGE
29.	Cell of Stöhrer's Induction Instrument	51
30.	Stöhrer's Small Induction Instrument	52
31.	„ Large Induction Instrument	53
32.	The Tibbits Combined Hospital Battery	56
33. 34.	The Tibbits Combined Portable Battery	57, 58
35.	Sponge-holding Rheophore	67
36.	Metallic Disc Rheophore	67
37.	Method of holding Rheophores	67
38.	Olivary Metallic Rheophore	68
39.	Conical Metallic Rheophore	68
40.	Method of holding Rheophores	69
41.	Ditto	70
42.	Ziemssen's Electrodes	72
43.	Motor Point for the Facial Nerve	73
44.	Electrization of Frontal Muscle	75
45.	Electrization of Zygomaticus Major	76
46.	Electrization of Buccinator	77
47.	Electrization of Sterno-Mastoid	79
48.	Motor Points of Anterior Surface of Left Arm	83
49.	Electrization of Median Nerve	84
50.	Motor Points of Anterior Surface of Left Forearm	86
51.	Electrization of Opponens Pollicis	87
52.	Electrization of Abductor Minimi Digiti	87
53.	Motor Points of Posterior Surface of Left Arm	87
54.	„ „ „ Forearm	88
55.	Electrization of Abductor Longus Pollicis	89
56.	Electrization of First Dorsal Interosseous	89
57.	Motor Points of Posterior Surface of Trunk	90
58.	„ Anterior „ Left Thigh.	93
59.	„ Posterior „ „	94
60.	„ Outer „ Leg	96
61.	„ Inner „ „	97
62.	Metallic Threads	99
63.	Rectal Rheophore	100
64.	Urethral Rheophore	100

PAGE

65. Double Vesical Rheophore (closed) 101
66. The same (open) 101
67. Uterine Rheophore (closed) 102
68. The same (open) 102
69. Laryngeal Rheophore 103
70. Aural Rheophore 104
71. Diagram of part of Tibial Nerve 116
72. Case of Atrophic Paralysis 147
73. The same (dorsal surface) 148
74. The same (after treatment) 149
75. The same (writing) 149
76. Case of Traumatic Paralysis (before treatment) . 151
77. The same (during treatment) 152
78. The same (after treatment) 153
79. Infantile Paralysis 159
80. The same 159
81. Another Case 159
82. Atrophic Paralysis of Muscles of Shoulder . . 163
83. Atrophic Paralysis of Deltoid 164
84. Muscles Developed by Faradization . . . 164
85. Atrophic Paralysis of Hand (before treatment) . 166
86. The same (after treatment) 166
87. Case of Torticollis 205
88. Another Case 206
89. Contraction of Rhomboid (before treatment) . . 211
90. The same (after treatment) 211
91. Electrolysis Needles and Needle Holders . . . 224
92. The Tibbits Galvano-Caustic Battery . . . 233
93. }
94. } Instruments for the Galvanic Cautery . . . 235
95. }

A HANDBOOK

OF

MEDICAL AND SURGICAL ELECTRICITY.

CHAPTER I.

ELECTRICITY AND ELECTRO-MEDICAL INSTRUMENTS.

Preliminary Remarks.

THE almost complete absence in the medical schools of the great hospitals of opportunities for an adequate study of electro-therapeutics, the importance of the subject, and the wide-spread attention that it is awakening throughout the profession, have determined me to sketch as briefly as is consistent with clearness the present position of the science and practice of medical electricity, and especially of its practice.*

* This observation, written in 1873, requires some qualification now (1877). At several of the medical schools, though not at all, electrical treatment has been transferred from the hospital porter to some member of the hospital staff, and at more than one a systematic course of lectures upon electro-therapeutics has been delivered. But it is still too common for the physician to consider (as quoted by Golding Bird nearly thirty years since) that when his fiat has gone forth "Let the patient be electrified," he has done all that is necessary; while the patient usually carries out this mandate by the purchase of a rotary magneto-electric machine and by using it according to the directions of its maker, who is generally about as well fitted to teach its application in disease as is the maker of an amputating knife to operate with it.

Preliminary Remarks.

I need hardly recall to mind, that until quite recently, to venture to speak of electricity as a curative power was pretty certain to result in the speaker being branded as little better than a quack. And even now, although this universal scepticism has disappeared, ninety-nine out of every hundred medical men content themselves with the theoretical belief that in certain cases electricity may do good, without themselves using it; but I hope that before long it will be as common to see an electrical instrument on the consulting-room table as a stethoscope or an ophthalmoscope. Indeed, I think that nothing but the want of information as to the choice and management of instruments can explain the little headway that the *practice* of electricity has made with the mass of the profession—too much occupied in their daily work to spare time to study the uses of this agent in the hands of the very few physicians in this country who have given attention to the subject.

I assume on the part of the reader an acquaintance with the elementary facts of electricity, such as may be gathered from any handbook on the Elements of Natural Philosophy. It will be no part of my object to discuss these facts, except incidentally with strict reference to their application to medicine.

In the first place I propose to describe the instruments which experience has proved to be reliable

and not inordinately expensive, and how to keep them in good working order (a point of no little importance); and then, in full detail, how to use them. Afterwards I shall very briefly discuss their diagnostic and therapeutic application, and quote either from my own experience, or from that of others, a few illustrative cases, referring for further examples to the many and voluminous writings of the German and French electro-therapeutists. Preliminary Remarks.

Nomenclature.

Firstly, a word or two on nomenclature. Nomenclature.

Throughout this Handbook the following terms will be used:—

Electrization.—The generic word for the application of electricity in therapeutics, and never to be made use of in any special or limited sense.

Franklinism: Franklinization.—*Friction or Static Electricity.*—The oldest known variety, the electricity of glass and amber, that with which the name of Franklin will always be associated.

Voltaism: Voltaization.—*Voltaic, Galvanic, Dynamic, Contact or Current Electricity, the Constant Current, Galvanism.**—The electricity of chemical action, that of Volta and Galvani.

Faradism: Faradization.—*The Induced Cur-*

* "*Galvanism*," although commonly used, is improperly applied as a designation of Voltaic electricity.

*rent, Electro-magnetism, the Interrupted Current.**— The currents of momentary duration discovered by Faraday to be generated or induced in a coil of copper wire by the action upon it, under certain conditions, of a permanent magnet, or of a voltaic current.

Of Instruments.†

Instruments.

To describe the many varieties of instruments in the market would alone fill a large volume. I propose only to refer to those which after numerous trials have been finally adopted for use at the National Hospital for the Paralysed and Epileptic as the most reliable, efficient, and, wear and tear considered, the cheapest. There are doubtless many others good and serviceable, but I have felt that the reader will rather thank me for not fatiguing him with an account of them all; and for relieving him as much as may be from the trouble of selection.

Franklinism.

Franklinism.

Franklinism is most conveniently generated by a Plate Machine in which the electricity arising

* The word "*interrupted current*" is most improperly applied to these induced currents. Its use should be strictly limited to breaks or interruptions of a true voltaic current.

† *The reader is strongly advised to satisfy himself that any instrument he may purchase is the manufacture of the original maker. Duchenne's instruments can only be obtained* PROPERLY MADE *from Charrière, of Paris; and Stöhrer's, if genuine, are stamped "Dr. E. Stöhrer, Dresden." Unless this rule is adhered to disappointment will result, and the therapeutic application will be unsatisfactory.*

from the friction of the rotating glass plate against the upper and lower cushions, is collected by two brass arms and distributed to the brass conductor, Franklinism.

Fig. 1.

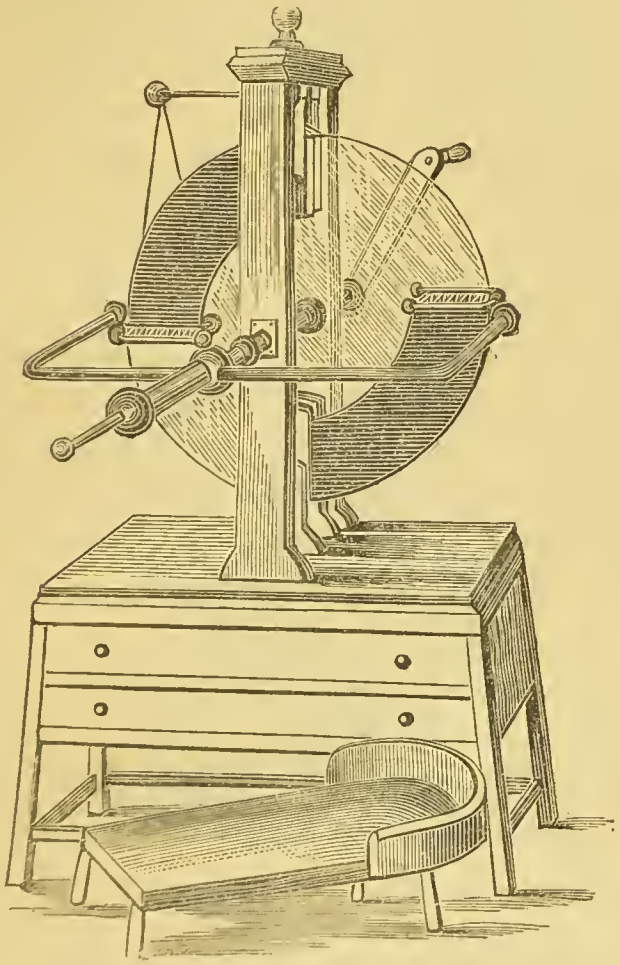


Plate Electrical Machine and Glass-legged Stool.

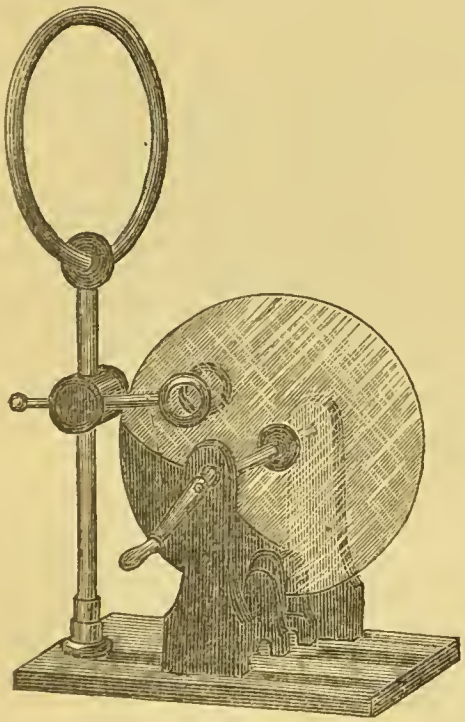
from which they branch out, and which is insulated by a glass support. I should recommend a machine with a plate of about two feet in diameter.

Franklinism. The machine should be fixed upon a firm stand or table, that it may be quite steady during rotation. The one that I habitually use is firmly screwed to a heavy painted deal table; and is shown in fig. 1. There will also be needed a Leyden jar, two or three lengths of brass chain, or preferably of copper wire insulated by gutta-percha; a couple of excitors insulated by glass handles; and a stool about four feet by two feet, with four glass balls or legs. A stool of this size admits of a chair being placed upon it, and it will be also useful for certain applications of voltaism, which will be mentioned later on. Four glass jars are also needed with which to insulate an ordinary couch. Care should be taken not to smear the cushions with too much amalgam, which had better be bought ready prepared. A piece about the size of a grape for each of the four cushions will be enough, and no more need be added for two or three months. The cushions should be screwed sufficiently tight to slightly "grip" the plate, and if it is found that notwithstanding having well warmed a flannel and rubbed all the glass of the apparatus with it, and especially the legs of the stool, that the instrument is not acting well, remove the cushions and warm them thoroughly. Always scrape off old amalgam before using new. *It is impossible to be too careful that everything is warm, clean, and dry,* for the great obstacle that exists against the extended use of Franklinism is

found in the difficulty sometimes present, from neglect of the above precautions, in getting the machine to act well, a portion of its electricity being conducted away by the moisture contained in the air as rapidly as it is generated. But even on a foggy day the instrument, with proper care, may

Franklinism.

Fig. 2.



Winter's Machine.

be made to act well by placing it in front of a fire for half an hour, or thereabouts, before use. The operator should also remember that dust must be sedulously guarded against. A few drops of petroleum may be sprinkled upon the table, and their

Franklinism.

vapour condensing upon the machine will aid in protecting it against moisture. For anything like sustained work the instrument described is from its simple construction superior *in practice* to any such as Holtze's and Carré's, which are theoretically more perfect; but where portability is an object, excellent results may be obtained from a Winter's machine with a plate of only fifteen inches in diameter, and which is easily carried. In this instrument (fig. 2) the fact that the quantity of electricity which may be accumulated upon a conductor is dependent upon its size, has been most ingeniously applied, the surface of the conductor being enormously increased by the insertion into a large wooden ring of a core of thick iron wire. Electricity accumulates upon the wire, and is prevented from escaping by the insulating wooden covering.*

Voltaism.

Voltaism. Requisites of a Voltaic Battery.

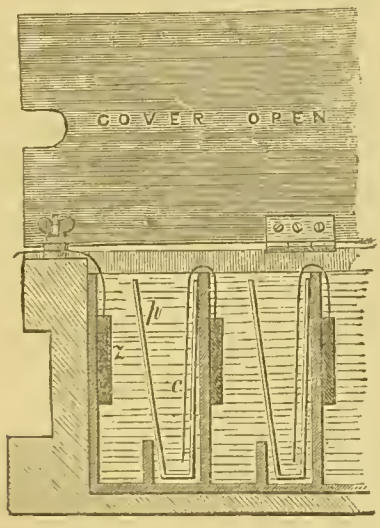
The essential requisite of a voltaic battery for medical purposes is that the current of electricity which it supplies should not only be *continuous* but *constant*—should not vary appreciably in power during the application. Any battery which does not fulfil this requirement should be unhesitatingly rejected.

* The price of the plate machine and table is 10*l.* 10*s.*; of the Winter's machine 3*l.* 15*s.* These machines may be obtained from Mr. Groves, 89, Bolsover Street, W.

The Becker-Muirhead Battery is a modification of Daniell's, and is that usually employed for telegraphic purposes. Its tension is low, but its action is very uniform. The elements consist of an unamalgamated zinc plate (fig. 3, *z*), and of a thin copper plate, *c*. The copper plate is immersed in a solution of sulphate of copper contained in a porous

The Becker-Muirhead Battery.

FIG. 3.



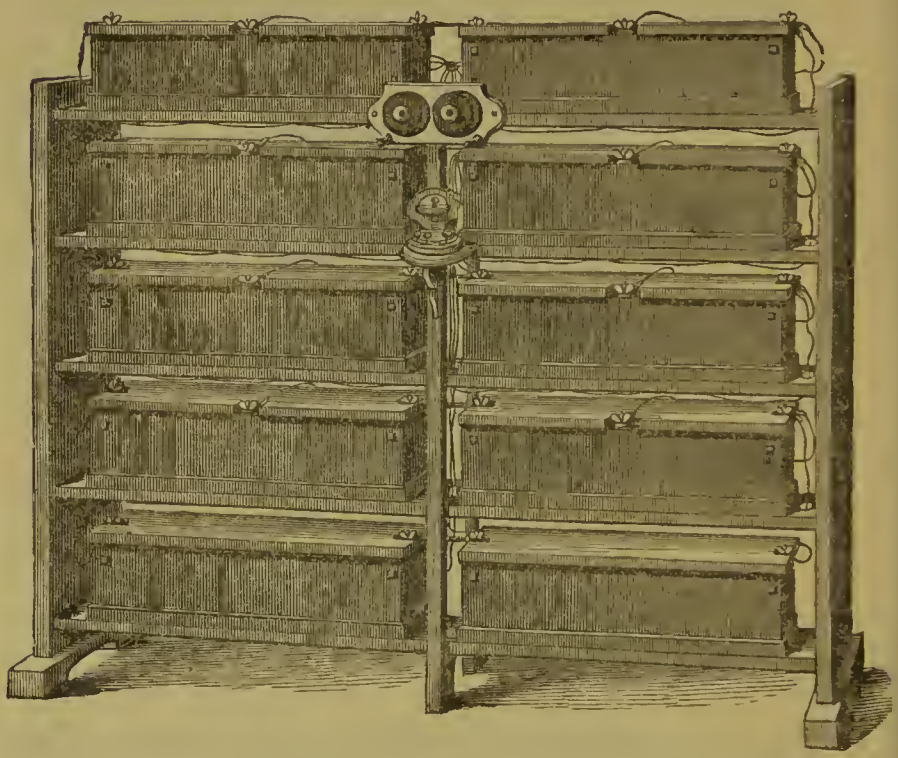
Muirhead's Battery.

cell, *h*; the zinc plate is immersed in water only, contained, with the porous cell and its contents, in a quadrangular porcelain vessel. The porcelain vessels are constructed in couples, each couple holding two pairs of elements, and five of these couples are packed in a strong oak box. The arrangement of the battery adopted at the National Hospital, as least complex, is shown in fig. 4, in which ten boxes

The Becker-Muirhead Battery.

containing one hundred pairs of elements are placed upon a simple open stand. The pairs are grouped in sets of five, and the terminal wires of these sets are attached to buttons in rear of two revolving disks, numbered respectively from 5 to 45, and from

Fig. 4.



The Becker-Muirhead Battery as arranged at the National Hospital for the Paralysed and Epileptic.

50 to 100. By turning the disks the operator, without detaching the conducting wires with which the excitors are connected with the instrument, can bring into play the current from as many sets of cells as he desires. When in daily use the

cells require to be re-charged and the zincs cleaned every two months, and new zinc plates are needed about every three years. This battery was designed by the late Mr. Becker, of the firm of Messrs. Elliott Brothers, 449, Strand, and it is supplied by them. The Becker-Muirhead Battery.

Mr. Becker added to it, as a means of ascertaining its state of action, and as a guide to the operator, an ingeniously constructed tangent galvanometer. The battery when freshly charged and all connections cleaned is in its most effective state, but as the strength gradually diminishes it is important for the medical practitioner to be able to ascertain at any given time the degree of diminution, so that he may determine the number of cells to be used in any given case. The terminals of the galvanometer coil are connected with a simple commutator so that the current may be made to traverse the galvanometer or not. When the battery is in perfect action it has been found that

5	cells	give	45°	deflection	of the needle	of the galvanometer.
10	„		57°	„	„	„
20	„		67°	„	„	„
30	„		70°	„	„	„
50	„		71°	„	„	„
100	„		73°	„	„	„

Should five cells only give 22° deflection, the battery would be half its strength (if for the sake of illustration we take the angles for the expression of the strength instead of the tangents), and a higher

The Becker-Muirhead Battery.

number of cells should be placed in action, where before five were sufficient.

This battery has been in use at the National Hospital, and in my own private residence for several years. With ordinary watchfulness of its state of action, and care and regularity in re-charging and cleansing, it has proved a very effective and trustworthy instrument, and from the simplicity of its construction it can be cleaned, re-charged, and repaired with facility by an ordinarily intelligent artisan. Giving off no fumes or odours, it may be placed in any room without hesitation, never becoming offensive. In my own house the battery is placed in a closet on the area floor, and the conducting wires are brought into the consulting-room and attached to the disks there. To clean and re-charge it, all that is necessary is to scrape the zinc plates, which become very foul, and to wash them, as well as the copper plates and porous cells, in cold water, and to refill the porous cells with a saturated solution of sulphate of copper, and the porcelain vessels with fresh water. The porous cells, which are very cheap, occasionally become clogged, when it is better to replace them, for which purpose a few spare cells should be kept on hand. In very hot weather when evaporation is rapid, it may be well to add a little fresh water without dismounting the battery, but this is very seldom required. If residing in town it is better to contract with the maker to do the

re-charging, of which the cost is about a sovereign. The price of a 100-cell battery is 25*l.*—of a 50-cell battery, 15*l.* 15*s.* The Becker-Muirhead Battery.

All connections, binding screws, &c., of electrical instruments must be kept scrupulously clean, and to do this nothing is better than to rub them occasionally with a bit of very fine emery paper.

The single drawback to Muirhead's battery is that it is not portable; but in every other respect it far surpasses any with which I am acquainted, and no portable battery can approach it either in regard to quantity of electricity, therapeutic result, or comparative absence of pain in application; but it occupies a large space, and as long as patients are not always movable, an efficient portable battery, as facilitating the use of electricity, both in diagnosis and treatment, becomes a *sine quâ non*.*

The profession is indebted to Stöhrer, in Germany, and Messrs. Weiss, and other makers in this country, for excellent portable batteries, which are unsurpassed by any fluid batteries in efficiency of action and compactness consistent with efficiency. But all portable *fluid* batteries possess certain inherent disadvantages and petty annoyances and difficulties

* Currents from large fixed batteries are less irritating in application, and their curative effects are more marked than those from small batteries, owing to their currents being of low tension and great quantity —the quantity of electricity depending altogether upon the size, and the tension only upon the number of elements.

Disadvantages of Portable Fluid Batteries.

inseparable from their management. They grow weaker from chemical decomposition and from evaporation, are subject at times to much uncertainty of action, require a good deal of care to maintain their efficiency, and are particularly liable to be rendered unserviceable from spilling of the acid in consequence of being knocked over by a careless attendant, as in transit by a railway porter—an accident damaging at times to carpets or to the operator's clothes. Moreover, to put these instruments in action some arrangement is necessary by which their elements are either lowered into the acid, or this is lifted to them; and in either case, if from forgetfulness the plates are left in the acid for a day or a night, they will probably be so damaged that an expense of several pounds will have to be incurred before the battery is again fit for use.

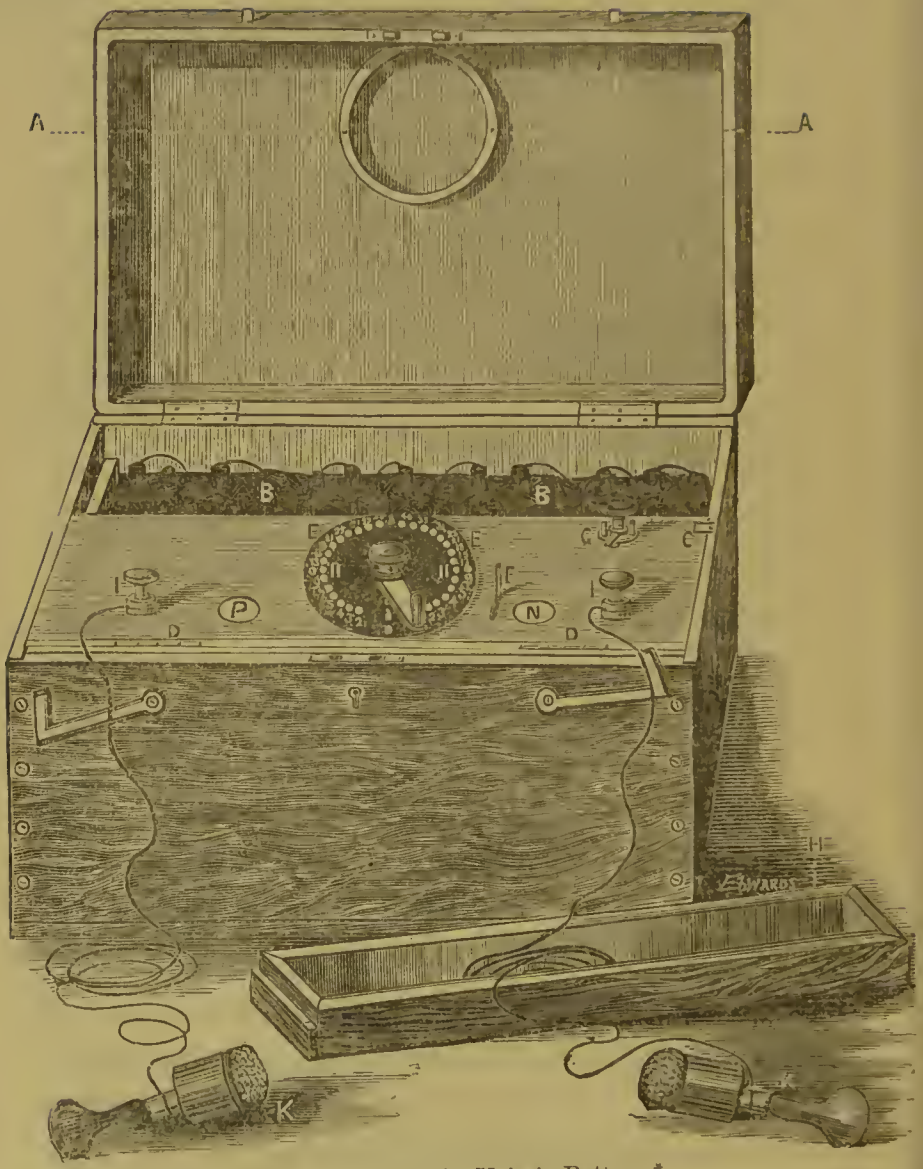
I have been experimenting for some years with the object of getting rid of these disadvantages; for at an early period of my electrical experience I suffered much trouble from fluid batteries. Remembering that the experiments of Matteucci upon nerve and muscle (the very basis of electro-physiology) were made with the old form of "Voltaic Pile," in which the chemical action liberating the electricity was set going by moistened blotting paper, my efforts were directed to the construction of a battery resembling this old pile in its power, but possessing constancy as well, and I was doomed to much dis-

appointment. But recently elements have been constructed by the patentees of the Leclanché cell, which are unquestionably superior of their kind to any others. They consist of a carbon plate placed in powdered peroxide of manganese within a porous cell, and a zinc plate inserted in moistened sal ammoniac, and they are remarkable for their constancy and persistency in action; for they remain, with ordinary work and without attention, in full efficiency for quite twelve months, and can even then be readily renewed. The Leclanché Cell.

Efficient cells are, however, but a first step to the perfection of electrical apparatus, and the mechanism by which the current is brought into use and graduated, and the general accessories of the instrument are of at least equal importance. The details of construction of the instruments which I am about to describe, and which have been made by Mr. Hawksley, of 300, Oxford Street, have been designed by myself, and it is claimed for them that they place at the service of the busy practitioner a battery that, with ordinary care (and no instrument will remain in order without this), may be kept upon his consulting-room table, always as available to his service as his stethoscope or ophthalmoscope.

Mr. Hawksley constructs these batteries with any required number of cells from 15 to 100, but the 30–40 and 50-cell batteries are the more generally useful.

Fig. 5.



40-Cell Tibbits Voltaic Battery.*

The Tibbits Battery.

The Tibbits Voltaic Battery.—Fig. 5 has its cells

* A. Guard preventing the lid being shut, unless the needle of the dial points to "0," and the instrument is out of action.

arranged in the interior of a mahogany case, and in use they are hidden from view and from danger; but in the figure they have been partially exposed by the removal of the tray for holding the sponges and accessories. Their connecting wires are brought to the under surface of the element board, which is made to move upon hinges, so that, when necessary, the cells may be examined; but at other times this element board is held in position by the bolt, C; and it should never be needlessly disturbed. These wires conduct the current through the graduating dial, E, and the position of the needle of this dial (enlarged in fig. 6) determines from how many of them the current shall be allowed to reach the binding screws, I, I, and from them by way of the conductors, sponge-holders, or electrodes, the body of the patient; or whether it shall be entirely shut off, as is the case when the battery is not in use, and when the needle stands at "0," the position it

The Tibbits Battery.

B, B. Cells shown by the removal of the compartment, H, for sponges and accessories.

C. Bolt to secure the element board, which moves upon the hinges, D, D.

E. Dial plate regulating the strength of the current. The needle, when the battery is not in use, should cover the stud, "0," seen to its left.

F. Commutator of the poles. The poles, N and P, are seen through holes cut in the element board.

G. Key by which the current can be shut "off" or "on," without change of position of the conductors. It can also be used by vibrating it backwards and forwards as an "interrupter."

I, I. Binding screws, to which are attached the conducting wires and sponge-holders, &c.

The Tibbits Battery.

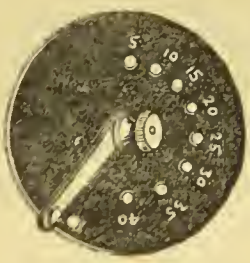
should always occupy whenever the electrodes are not in actual contact with a patient. For the cells being always in action, *fouling of the elements and weakening of the battery will result if the conductors remain in contact with each other, or in a vessel of water, while the current is passing through them.* When the needle points to any stud numbered on the dial, the number of cells marked on that stud are brought into action, and the needle is made just wide enough to touch one of the studs before it breaks contact with the preceding one, and thus the current may without shock be increased or decreased in power, while the electrodes are held applied to the patient.* Should the needle, from forgetfulness, be left, after use, in any other position than at "0," a guard, A, upon the lid of the instrument prevents its being shut, and the operator has his attention called to his inadvertence. A voltaic alternative, or change of direction of the current, is sometimes required in treatment, and the commutator of the poles, F, enables this to be accomplished without alteration in the position of the conductors. By pushing forwards or backwards the handle, which moves a lever working below the element board, the current is instantly reversed, and the alternation of the letters "P" or "N," seen through holes cut in the

* In fact the needle becomes a "Rheostat," and if it were not constructed as described in the text, a series of painful shocks would be communicated whenever the current was increased or decreased.

element board, indicates at once not only that there has been a change of poles, but which pole is *at the moment negative or positive;* whereas, in all previous instruments, when the poles have been changed, there has either been no letter marking them, or this letter has really been wrong, and one has had to remember this. Under such circumstances, and when examining patients in rapid succession, momentary confusion of the poles was very liable to occur even to a practised operator. A key, G, enables the current to be shut off or on without removal of the conductors. The Tibbits Battery.

Dirt is a non-conductor of electricity, and the studs of the dial must be kept clean with emery paper or plate powder—as also the under surface of the needle, key, and binding screws, all of which unscrew, and admit of removal.

Fig. 6.



Graduating Dial.

In the daily use of a battery the chief work is usually thrown upon the first half (say in a battery of 40 cells, upon the first 25 cells), and various arrangements have been added to batteries by

The Tibbits Battery.

ingenious instrument-makers, to enable the operator to vary his selection of the cells to be brought into use, and thus to relieve the first half of his battery, or, in other words, to equalize its work. But this unequal work question is more a theoretical than a practical evil, for if the initial cells grow weaker, a greater number can be placed in use. I have carefully studied all the proposed modifications, and have found in all of them the remedy worse than the evil, unless the graduating dial be doubled (an original suggestion of my own), so that the initial cells of one week may be made the terminal cells of the next; and Mr. Hawksley constructs batteries, when desired, with this double dial.*

Fig. 7.



New form of Graduating Dial.

Returning to the consideration of portable fluid batteries, one of the best is that designed by Mr.

* It is much better to obtain these batteries charged and ready for use, and this is usually done before they leave the workshop; but charged batteries do not improve by travelling unattended, and being

Foveaux, of the firm of Messrs. Weiss and Co., 62, Strand.

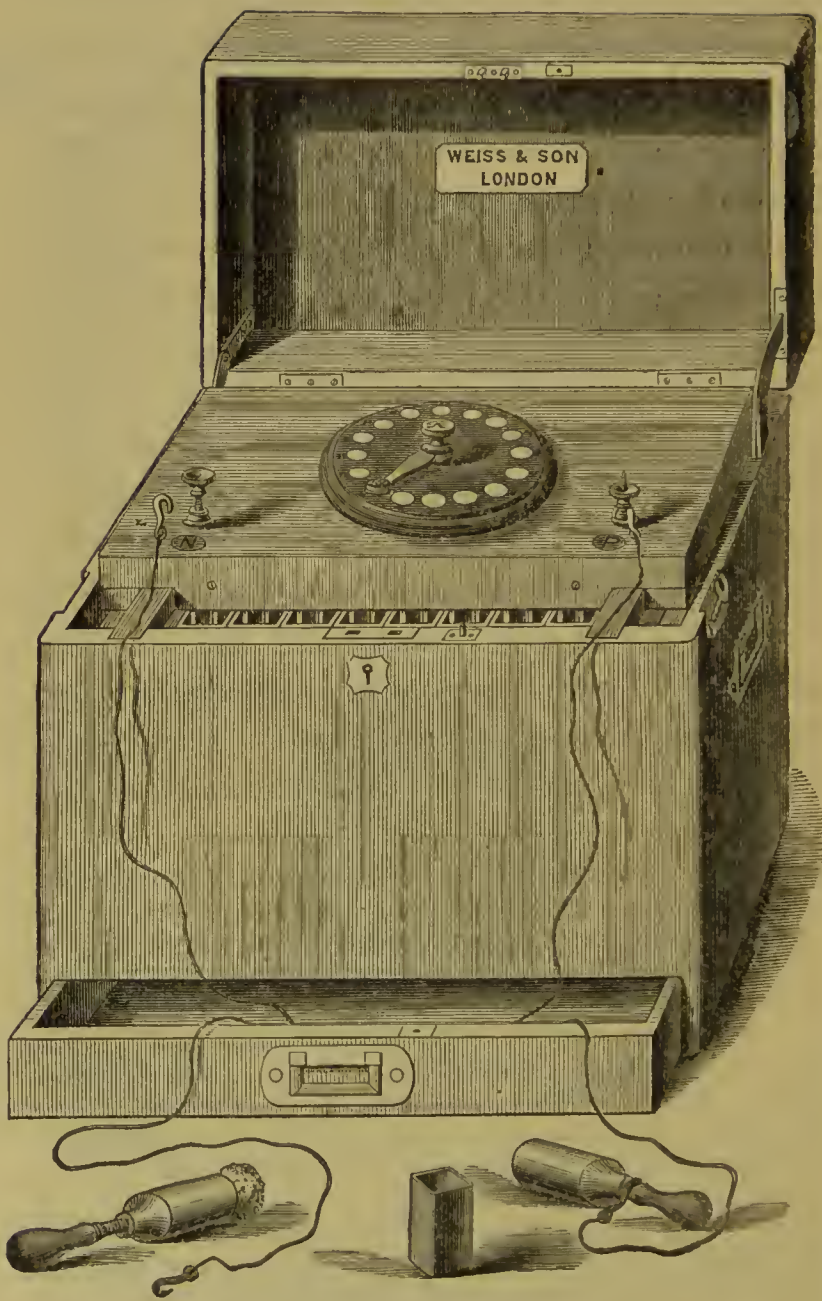
Foveaux's Portable Battery is formed of pairs of Smee's elements, packed into a handsome mahogany box, which measures in length 14 inches, in breadth 7½ inches, and in height 10¼ inches (fig. 8). The cells containing the exciting fluid (diluted sulphuric acid), and which are constructed of porcelain, are attached to an ingeniously devised lifting arrangement. When the lid of the box is closed, and the battery is out of use, the cells and the contained exciting fluid are depressed beneath the elements, and the latter are no longer immersed. When the lid of the battery is raised to place the instrument in use, the cells are elevated and the elements immersed. By this arrangement the zinc is withdrawn from the destructive action of the acid when the apparatus is not in use, and the waste of the

Foveaux's Portable Battery.

thrown about by railway officials and others as if they were portmanteaus! so that it may sometimes be necessary to charge the battery oneself. To do so proceed as follows:—Remove the cork closing the opening into each cell and through this opening inject with a syringe six drachms by measure of water. This is a delicate and tedious operation, and as some time is occupied in saturating the contents several injections may have to be made, and it is *very important that no water be allowed to run over between the cells or secondary action will be set up and injury to the battery will result.* If there is extra difficulty in introducing the water into any one cell a knitting needle or piece of stiff wire may be carefully passed through the opening and the cell contents be *very* slightly stirred. Each cell must receive the full measure of water above indicated, the corks must be replaced tightly, and in three hours the battery will be ready for use, and it will so continue for months. *Unless the above directions are strictly adhered to failure will result.*

Foveaux's Portable Battery.

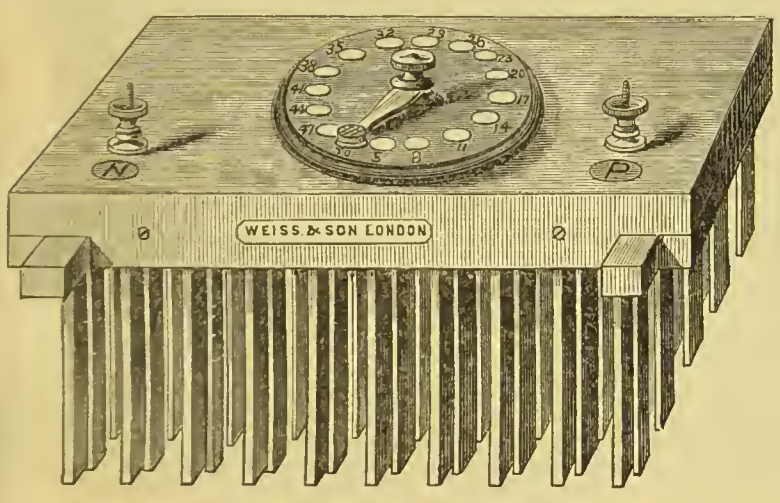
FIG. 8.



Foveaux's Portable Battery.

elements may be obviated to the greatest extent. It requires, in constant daily use, to be charged about once in two months, by pouring into each cell a measured portion of diluted sulphuric acid (one part of strong acid to twenty-nine of water). A measure holding the requisite amount of acid is supplied with the instrument. To charge it the plates can be lifted out of the cells *en masse*, as shown in fig. 9, without any trouble in dismounting them. Foveaux's Portable Battery.

Fig. 9.



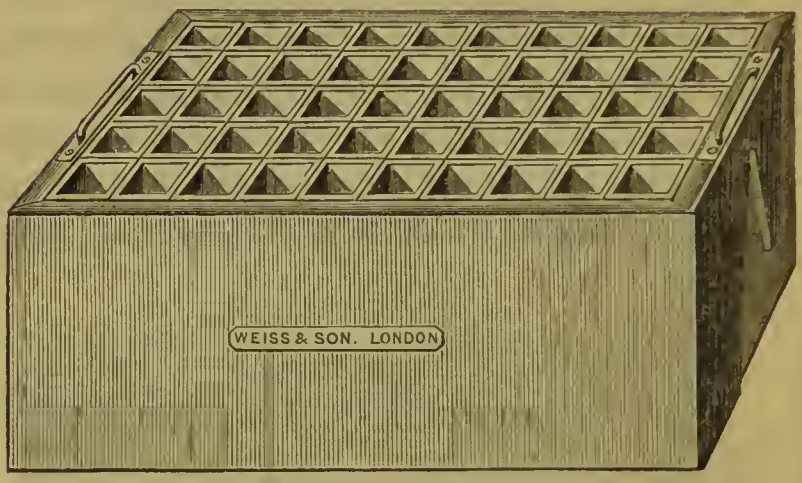
The Elements of Foveaux's Battery.

The elements being lifted out, the arrangement of the cells is seen in fig. 10. By means of a dial plate with a movable needle, the current is graduated without detaching the conducting wires. The battery is mounted in sizes varying from twenty to sixty cells, and in price from 6*l.* to 15*l.* 15*s.* The more generally useful sizes contain

Foveaux's Portable Battery.

thirty and sixty elements. I have used Foveaux's battery chiefly in cases in which the interrupted

Fig. 10.



The Cells of Foveaux's Battery.

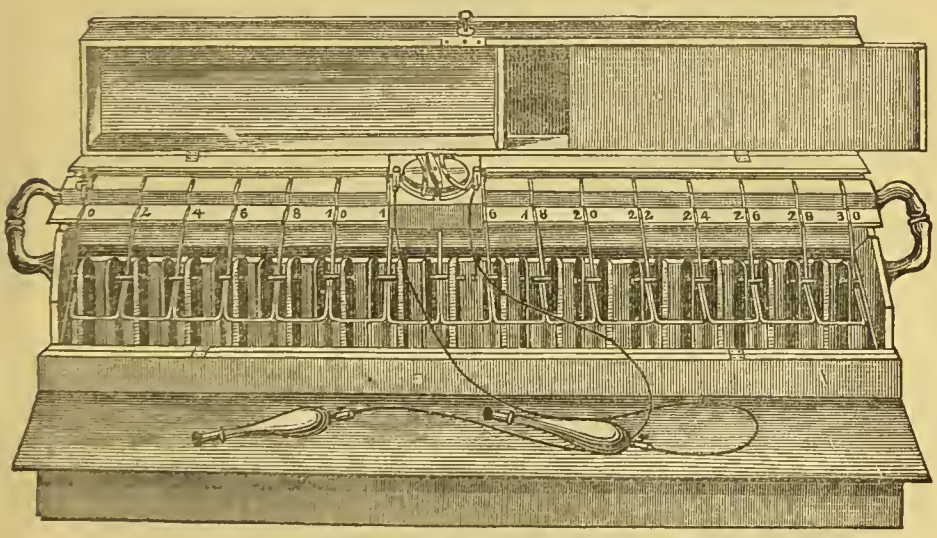
voltaic current has been required to be used for diagnostic purposes. It is an exquisitely made instrument.

Stöhrer's Battery.

Stöhrer's Battery with Lifting Apparatus.—Stöhrer of Dresden has constructed a very excellent battery for medical purposes. The elements, consisting of carbon and zinc, are attached in pairs to a wooden rail, and project into glass vessels, which serve for the reception of diluted sulphuric acid, and which are so arranged in the completed apparatus, that they can be moved vertically up and down, and fixed in any position. By this arrangement the acid can be brought into contact with the zinc and carbon, or by shutting down the cells be excluded

from them altogether. In the latter case the acid will only fill the lower third of the glass, and it is hardly possible that it can be spilt. Should, however, such an accident be apt to occur, a small stopper of caoutchouc at the left side of the base must be pulled out, and the instrument slightly inclined, that the acid may run out. The conducting cords are attached, as shown in figs. 11 and 12, Stöhrer's Battery.

Fig. 11.



Stöhrer's Battery for Hospital use.

to a simple and easily adjusted slide running in a groove upon the bar that supports the elements, and at its lower surface being in metallic connection with them. By the movement of the slide, any desired number of cells can be brought into operation; and on its upper surface is an ingeniously devised commutator, by turning which to the right

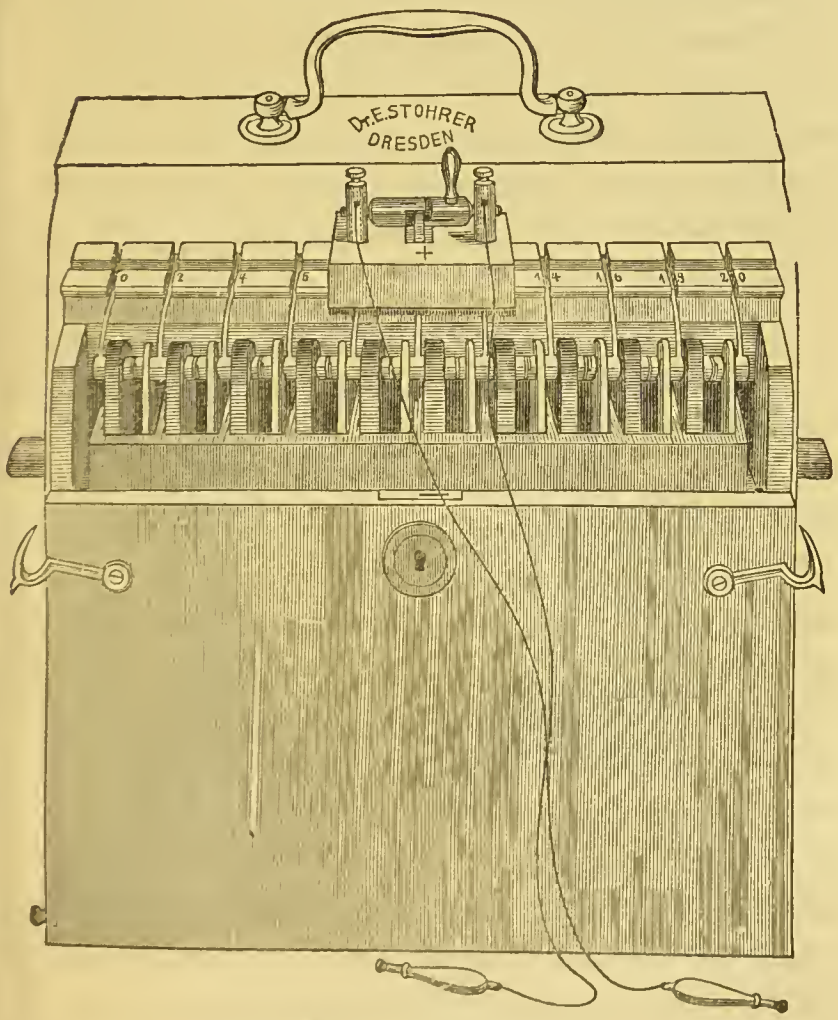
Stöhrer's Battery.

or left, the current admits of being reversed without removal of the conductors. The bar is marked from left to right with ciphers corresponding with the number of the elements, and their points of attachment, and it is of importance that the *centre* of the slide should be placed in a line with this attachment, as shown in fig. 11, in which fourteen, and in fig. 12, in which ten cells are in use. If this rule is neglected, rapid decomposition with development of gas, weakening of the current and general fouling of the instrument will result. In frequent use, re-amalgamation of the zincs will be required about once in six months, or whenever during use effervescence of the acid is perceived. To re-amalgamate the zincs allow each plate to remain for about a minute in diluted sulphuric acid (one part of strong acid to seven parts of water) for which purpose a common tumbler answers well. Hold the plate over a second empty tumbler, and pour upon it about a teaspoonful of quicksilver. Rub the quicksilver well over the plate with a piece of sponge until it is quite bright; replace the plate for a moment in the acid, and notice if any bubbles of gas are evolved; if so, the amalgamation is imperfect, and more quicksilver will be required. If no gas is generated, rinse the plate for a moment in tepid water, and stand it aside to dry. At the same time the carbons should be soaked for about five minutes in tepid water (not hot), to dissolve the zinc salts with which

they become encrusted. They may be also scrubbed with an old nailbrush or toothbrush. Clean all metallic connections with emery paper, and do not screw the carbons and zincs together again until

Stöhrer's Battery.

Fig. 12.



Stöhrer's Portable Battery.

they have been allowed to dry for twelve hours. Charge each cell with a solution of one part of

Stöhrer's Battery.

strong sulphuric acid to nineteen of water, and put in each a pinch (about as much as a pinch of snuff) of sulphate of mercury, which will greatly contribute to preserve the amalgamation of the zincs. Dr. Stöhrer constructs this battery in several sizes, varying from thirteen to forty pairs of elements (fig. 11), adapted for hospital use; and in a portable form (fig. 12) of essentially the same construction, but smaller and lighter. It is a most efficient and serviceable instrument, and equal to all the requirements of electro-therapeutics. Its price is from 6*l.* to 15*l.* 15*s.*

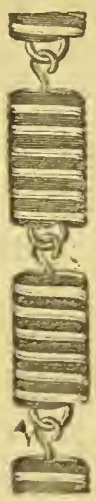
Pulvermacher's Chain Battery.

Pulvermacher's Chain Batteries.—As before stated, the fundamental requisite of a voltaic current for therapeutic application is its constancy. To obtain this property and at the same time a cheap and portable instrument, has been for years the effort of manufacturers. The most ingenious arrangement of the largest number of elements in the smallest space is to be found in Pulvermacher's chains. But in action they are *inconstant*. Steeped in vinegar they yield currents of high tension, but their action rapidly declines, and they become much weakened in a very short time. They may in the absence of a better instrument be occasionally of use for purposes of diagnosis, employed with electrodes in the same way as other batteries; but for therapeutical applications they are unsuitable, and worn upon the body as advocated by the inventor

they exercise little or no benefit, except perhaps in some cases where they appear to act from their electro-cutaneous excitation as counter-irritants. I am led to make these remarks and to describe these forms of battery from the very numerous letters of inquiry that I receive regarding them. The principle of their formation is that of the combination of a great number of elements, from 300 to 400, having but small surface. The original and best known forms of the chains are shown in figs. 13 and 14. The elements of which the

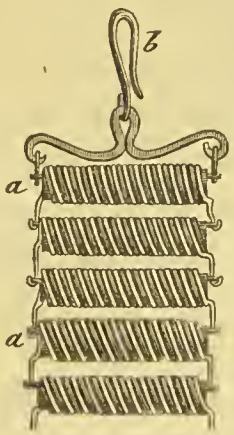
Pulvermacher's Chain Battery.

FIG. 13.



Pulvermacher's Galvanic Chain.

FIG. 14.



Another form of Pulvermacher's Galvanic Chain.

chains are now constructed are formed of a cylinder of copper plate perforated with longitudinal openings, and within this cylinder is a cylinder of zinc without perforation. The zinc is separated

from immediate contact with the copper by a few stout threads. An unbroken link which forms part of the copper cylinder serves as the means for joining the several segments. This construction permits the withdrawal and renewal of the zinc when necessary.

Faradism.

Requisites of a Faradaic Instrument.

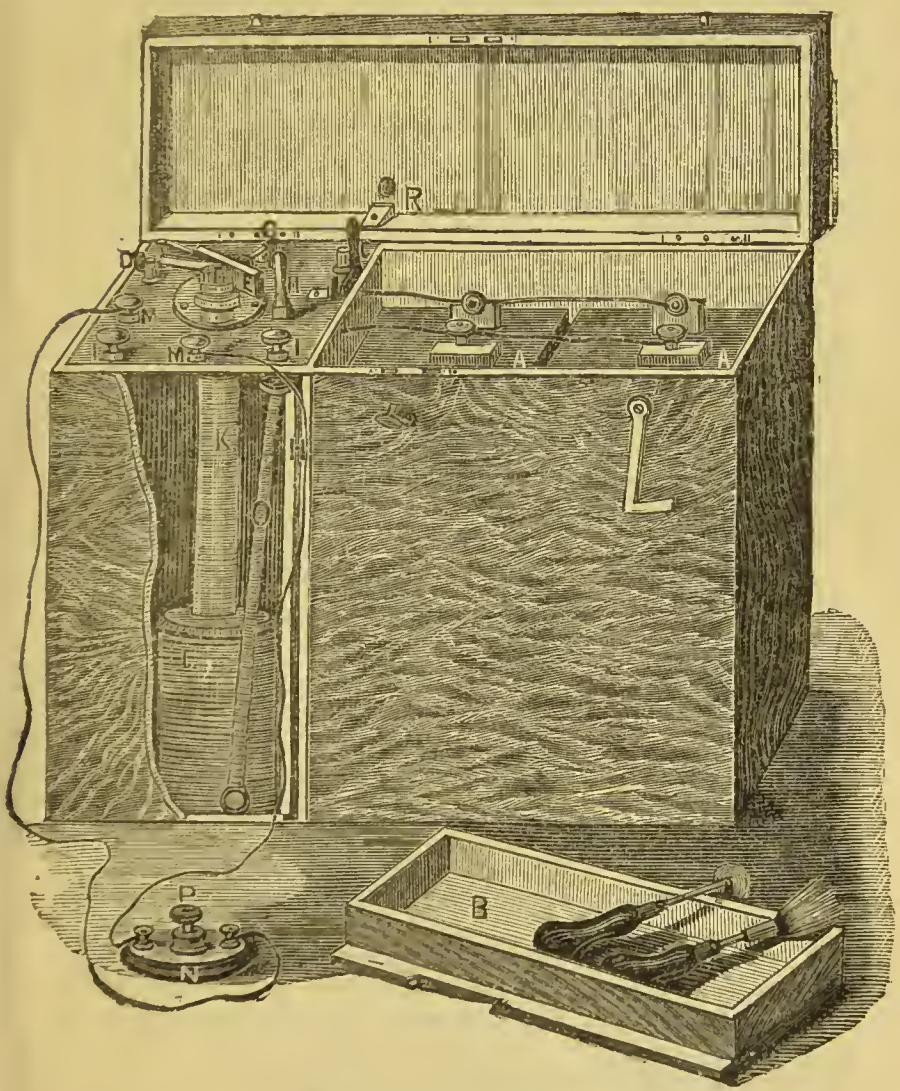
The essential requisites for a faradaic instrument are: 1. The possession of coils, constructed after certain proportions of thickness and length of wire. 2. A sufficient range of power. 3. An exact means of graduation. 4. Constant readiness for action; and capability of being placed out of action without trouble and loss of time.

The Tibbits Induction Battery.

The Tibbits Induction Battery.—I have adapted cells to this instrument similar in construction to those employed in my voltaic battery (page 16), but of larger size; and the amount of wire in the coils has been experimentally proportioned to the electromotor power of these elements. The instrument is shown in fig. 15, the cells, A, A, being visible by the removal of their cover, B. The primary coil, L, is fixed upon a pedestal; the secondary is movable, and is brought into and placed out of action by being lifted over or thrust away from the primary. The degree of action in the secondary coil being proportionate to the extent to which it is brought under the influence of the primary, the arrange-

ment described admits of the most perfect gradua- The Tibbits Induction
tion of the current, and it has been for some time Battery.

Fig. 15.



The Faradaic Instrument.*

* A. Cells shown by the removal of the compartment, B, for conductors and accessories.

The Tibbits Induction Battery.

in use in all well constructed instruments. The innovation that I have made consists in limiting the primary coil to its legitimate purpose of induction,

C. Key by which the instrument is brought into, and put out of, connection with the cells, A, A.

R. Guard which, in the act of shutting the lid, places the instrument out of action, if the operator has inadvertently forgotten to do so.

D. Screw regulating the pressure of a spring which modifies the vibration of the hammer, E.

E. Hammer vibrating between the electro-magnet, F, and the point of a platinized needle regulated by the screw, G.

F. Bundle of iron wires rendered an electro-magnet by the passage of the voltaic current from the cells, A, A, through the primary coil, K, within which this bundle of wires is inserted.

G. Screw regulating position of a platinized needle.

H. The graduator, a stem to which is attached the movable secondary coil, L. The front part of the case has been cut away in the engraving, to show the construction of the induction apparatus.

I, I. Binding screws for attachment of the conducting wires, &c.

K. The primary coil, fixed upon a pedestal. In the figure, the secondary coil, L, is wholly withdrawn from the action of the primary, and its strength of current depending entirely upon the extent to which it covers the primary, it is evident that the height which the graduator, H, stands above the element board will exactly indicate this strength.

L. Movable secondary coil.

M, M. Binding screws for attachment of the pedal rheotome, N, for slow interruption. These interruptions are made by the pressure of the operator's foot upon the spring, P, but in practice they are very seldom wanted, and the fittings are only added to the instrument when specially ordered.

O. A spring retaining the secondary coil, L, in any desired position.

The induced current is obtained as follows:—A wire from the positive pole of the cells, A, A, is connected through the key, C, with the needle at the end of the screw, G. Against the point of this needle the hammer, E, is maintained, when out of use, by the elasticity of the spring, regulated by the screw, D, and which is seen in the figure to press against the shaft of the hammer. A wire from the negative pole of the cells, A, A, is joined to one end of the wire of the primary coil, K, and the other end of this primary coil joins the hammer, E. The current from the cells,

and rendering the secondary alone available for application to a patient. I have been long satisfied that therapeutically the distinction between the primary and secondary coils entirely consists in the

The Tibbits Induction Battery.

A, A, being turned on by the key, C, travels to the needle, G, and as this needle is in metallic contact with the hammer, E, through this hammer and from it through the wire of the primary coil back to the cells, A, A, from which it set out. But this passage of a current through the primary coil causes the bundle of iron wires, F, inserted within it to become magnetic, and consequently to attract the iron hammer, which at once flies to it, the magnetism being stronger than the resistance of its spring. But this movement of the hammer from the point of the needle leaves an open space, *which breaks the circuit as completely as when a telegraph wire is cut.* Magnetism is at once abolished in the bundle of wires, and the hammer returns by the elasticity of its spring, no longer overpowered by magnetism, to the point of the needle. *By this return of the hammer the current is re-established,* and the same process is repeated, the hammer vibrating thus backwards and forwards many times in a second; and each time that it leaves, and each time that it regains the point of the needle, a momentary current is generated in the primary coil, K, and also in the secondary coil, L, if this latter at all overlaps the primary, the power of current in the secondary coil being directly proportional to the degree of this overlapping. We thus see that many "shocks" of induced electricity may be administered even in one second of time! The path of the current is seen in the diagram fig. 16. It starts from the battery, A, travels, as shown by the arrows, first to the coil, B, through this coil to the hammer, E, and from the hammer through the needle n' back to the battery. C is the bundle of wire rendered magnetic. It is obvious that when the hammer, E, is attracted to this electro-magnet, the space seen in the figures between E and C will exist between E and the point of the needle n'.

FIG. 16.

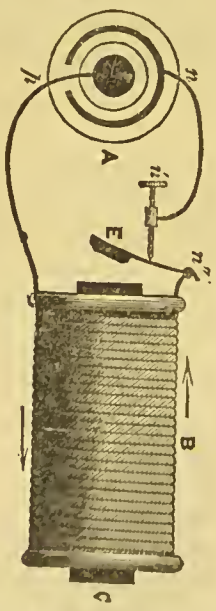


Diagram of path of current.

The Tibbits Induction Battery.

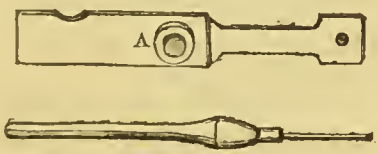
greater tension of the current of the secondary coil, enabling it to penetrate easily several thicknesses of muscle; but there is no therapeutic indication that cannot be fulfilled by the secondary coil, and at its lowest power I have frequently applied it to the conjunctiva. The rapidity of vibration of the interrupting hammer is varied by increasing or decreasing the distance between the point of the needle, G, and the electro-magnet, F—that is, by increasing or decreasing the space through which the hammer passes in its vibration—the protrusion or retraction of the screw of which the needle forms the end effecting this; also by altering the pressure of the spring, D; but there is seldom therapeutic need for change of vibration, and unless this exists, it is better *not to alter the adjustment as long as the instrument acts well.** After considerable use

* A little care is needed to regulate the vibrating needle. The spring, D, should but *barely touch* the hammer, the adjustment being almost entirely regulated by the protrusion or retraction of the needle by the action of its screw; and the *slightest twist* of this screw will be sufficient. When the vibration is uneven or stops, and careful manipulation of the needle fails to re-establish it, remove the needle and clean its point with emery paper; and if this does not avail, give the disk a *slight* turn with the lever, and bring a new surface of platinum into contact with the needle point. A coarse vibration with a large spark and harsh sound is not only more unpleasant to the patient but it will sooner exhaust the battery. A rapid even vibration with a small spark and little sound must be aimed at, and the adjustment regulated with that object. Care should also be taken not to screw up the hammer against the electro-magnet, but to leave enough space for its vibration. The coil should not be placed in action before it is required for actual use, and it should be put out of action directly the operation is finished, and

The Tibbits Induction Battery.

the point of the needle, G, and the exact spot of the platinum disk of the hammer against which this needle impinges, become oxidized with subsequent weakening or stoppage of the current. This platinum disk has been constructed to rotate, and a hole has been drilled in its circumference. By inserting the little lever delineated in fig. 17 into this hole, the *slightest* twist given to the disk is sufficient to bring a new surface of platinum into contact with the needle point. This will usually be all that is required; but if not, the needle can be unscrewed and its point cleaned with emery paper. When in course of time the disk becomes dotted over with spots of oxidation, the screw fixing the hammer in position must be unscrewed, the hammer lifted out and its surface similarly cleaned.

FIG. 17.



Platinum Disk and Lever.

I, I, are binding screws for the attachment of the conducting wires. Care should always be taken after use to "turn off" the battery current by the

in protracted applications it may occasionally be rested with advantage for a few seconds. By following these directions some practitioners keep their instruments fit for use for years; while others, less careful, exhaust theirs in a few months.

The Tibbits Induction Battery.

key, C, and to close the lid of the instrument. The guard, N, will prevent the shutting of the lid unless the current has been turned off; and if the operator has forgotten to do this he will be reminded of his oversight. In fig. 15 the instrument is shown at its lowest power, the secondary coil barely overlapping the primary at all; but in fig. 32, page 56, it is at a higher power.*

Duchenne's large Volta-faradic Instrument.

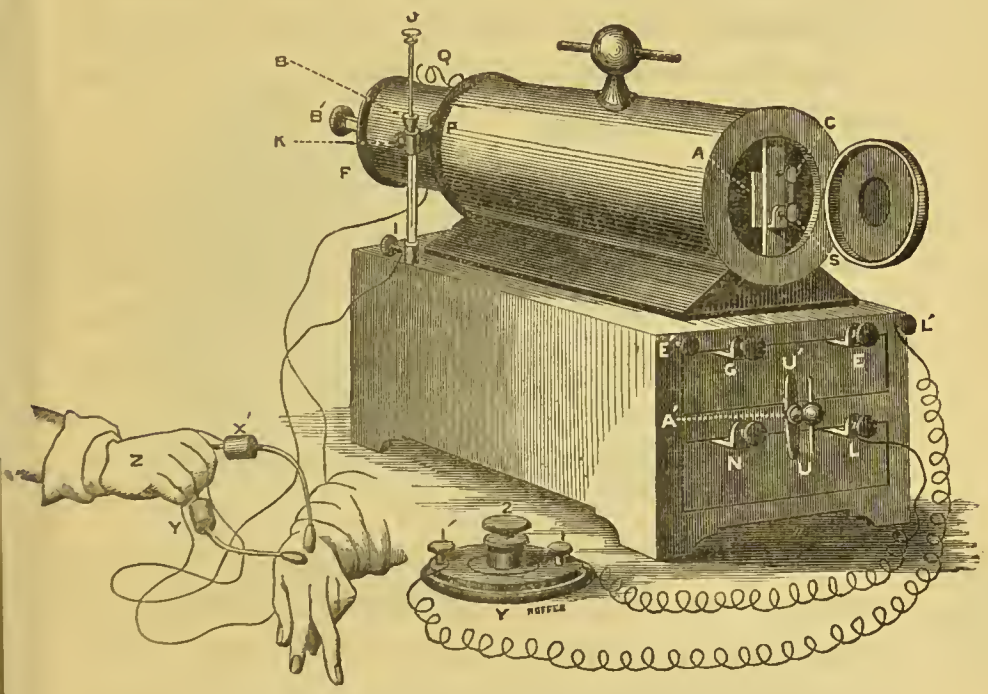
Duchenne's large Volta-faradic Apparatus.—In this instrument the two coils forming the systems of induction are composed of two copper wires differing in diameter and length, and covered with silk. The thicker and shorter of the two wires is rolled around a bundle of soft iron wire so as to form a coil (the *primary* coil); the finer and longer wire is rolled round the thicker and shorter coil, and forms the *secondary coil.* The ends of the coils terminate at the two springs of the commutator of the coils (E, fig. 19). This commutator is for the purpose of transmitting rapidly and alternately the current either of the primary or secondary coil to the conductors attached to the knobs P and Q (fig. 18), according as the needle (F, fig. 19) is turned to the right or left, as is shown on a plate situated above the needle. The battery which works the instrument is contained in the drawers, U and U′;

* To charge the battery see note, page 20. Proceed as there directed, but add a sufficient quantity of water to thoroughly saturate the cell contents.

but I can not recommend this battery, to the description of which Duchenne devotes some pages, and it is far better to procure the instrument without the battery, directing it to be affixed to a wooden slab, at the level of the binding screws, E′ and L′ (fig. 18), and doing away with the part

Duchenne's large Volta-faradic Instrument.

FIG. 18.



Duchenne's large Volta-faradic Instrument.

of the apparatus figured below E′ and L′. A couple of the cells used to work my Faradic instrument, already described, answer admirably for working Duchenne's, their polar wires being attached to E′ and L′. But whatever battery may be used let

Duchenne's large Volta-faradic Instrument.

it be entirely separate from the instrument, and its wires attached, when in use, to E′ and L′. The moderator is a glass tube, terminating below in a metallic base, to which is attached a knob, I, and above is a collar, K, from which proceeds a hook, which serves to connect the moderator with one of the knobs, P, which receive the conducting wires to the electrodes, and in which the poles of the coils terminate. In the collar is a small opening traversed by the stem of the moderator, J. The tube is filled with water.

The trembler is composed of a piece of soft iron (A, fig. 18), and of a platinized screw, S, against which the soft iron is pressed by a small spring. The pedal (Y, fig. 18) is to admit of slow intermissions being produced with the foot, an arrangement which leaves the hands of the operator free, either to hold the conductors or to graduate the currents.

Duchenne's large Uncovered Instrument.

Duchenne's large Uncovered Apparatus (fig. 19) differs from that just described in the following respects:—1. It has no external covering, so that the arrangement of the coil, A, and the movement of the cylinder, B, over it, may be seen. 2. It possesses two graduator cylinders; one, B, which acts upon the secondary coil; and another, C, upon the primary. 3. Its core of soft iron, D, is movable, and may be withdrawn so that we may study the influence of the tubes, B and C, independently of

temporary magnetization. 4. Besides the commutator of the coils, E, it possesses a commutator of the poles, H, forming part of its structure, and by which the directions of the currents may be rapidly changed without displacing the conductors. 5. The trembler is so constructed that the rapidity of the intermissions can be progressively increased

Duchenne's large Uncovered Instrument.

Fig. 19.

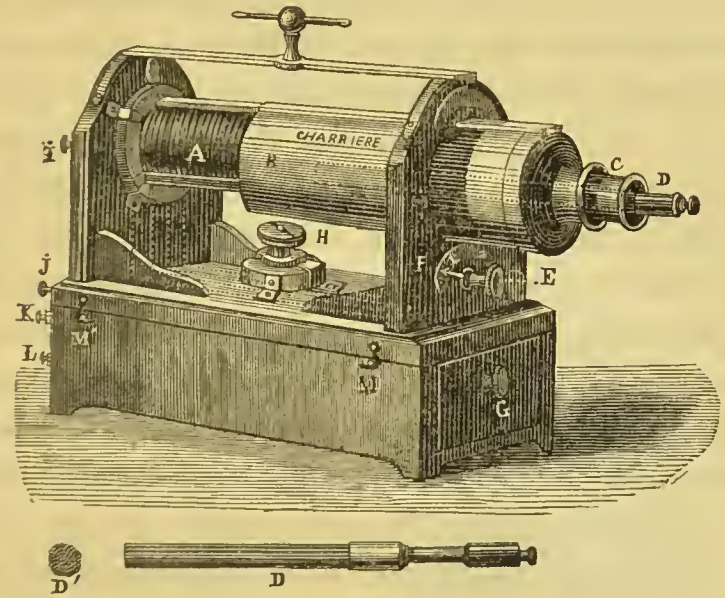


Fig. 20.

Fig. 19.—Large uncovered Volta-faradic Instrument.
Fig. 20.—Bundle of soft iron wire.

from four or eight in the second, to an almost incalculable number in the same period of time.

If it be desired to obtain rapid intermissions of the trembler (A, fig. 18), turn from right to left the knob, C, which fixes the movable plate. When

Duchenne's large Uncovered Instrument.

this is done the plate oscillates rapidly between the screw, S, and the temporary magnet of the central coil. If intermissions more or less separated from one another are desired, the button, C, is turned from left to right, so as to render the plate, A, of the trembler immovable, and a conducting wire is carried from one of the knobs, I′, of the pedal rheotome, Y, to the button, L′, a second wire being carried from the other knob, I′ (not as delineated in the figure to L), but to E′. The terminal wires of the separate battery being then also attached to I and I′, it is only necessary to govern with the foot the spring contact, 2, of the pedal rheotome, in order to make and break contact at pleasure. It is, therefore, perfectly easy to obtain intermissions separated by any desired interval. The pedal commutator is introduced between the battery and the coil by the arrangement of wires just described; and the battery current can only reach the coil when the operator presses his foot upon the spring, 2.

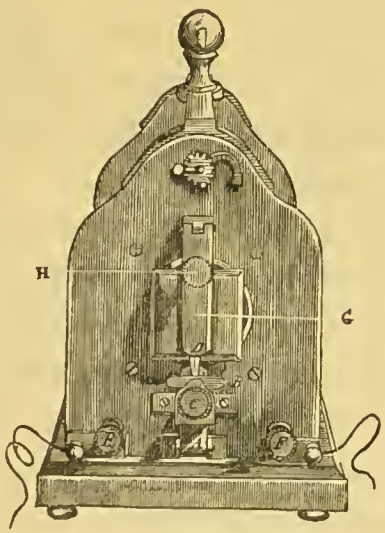
When the graduator, B, is entirely contained within the instrument, the currents are at the minimum of intensity; and, in order to increase them, it is only necessary to draw out this tube. The instrument being in action the conductors must be fixed to the knobs, P and Q, to which is brought the current of either the primary or secondary coil by turning to the right or the left the needle of the commutator. If it is proposed to measure in-

Duchenne's large Uncovered Instrument.

finitely weak doses the upper part, K, of the moderator, F, must be connected with one of the knobs, P or Q, and one of the conductors with the lower part of the moderator, I. Then the more the stem, J, of the moderator is drawn up, the greater will be the thickness of the water traversed by the current, and the more the latter will be weakened. The current may then be divided and measured by the tube graduator, B.

Duchenne also adapted to his uncovered instrument a special trembler, whose beats may be quickened or retarded at pleasure. It is shown in fig. 21, a front view of this instrument. One of the extremities of the wire of the primary coil communicates with the knob, E, the other with the screw, C. The movable piece of copper, A, which is pressed back by a spring placed in front of it against the screw, C, communicates with the knob, F. As soon as the knobs, E and F, are placed in communication with the poles of a battery, the current passes through the wire of the primary coil, and magnetizes its

FIG. 21.



Front view of the instrument shown in fig. 19.

Duchenne's large Uncovered Instrument.

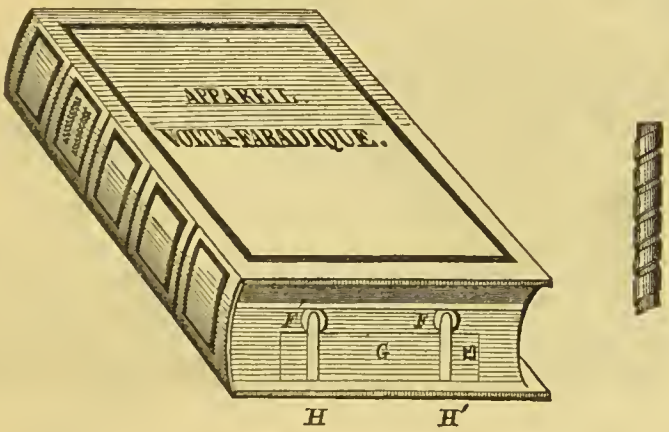
core of soft iron, which attracts the movable piece of soft iron, G. This draws with it the piece of copper, A, which was resting against the screw, C. A break of continuity is produced, demagnetizing the core, and causing the return of A to C. The same order of events continues, the current being re-established. When the screw, C, is tightened, the spring which presses the piece, A, against it, is sufficiently tense to cause the intermissions to occur without vibrations; but when the spring is relaxed by loosening the screw, each beat or intermission is followed by a vibration such that its slowest action (four intermissions per second) produces muscular contractions that are painful, although infrequent. These slow intermissions are sometimes highly useful. In the trembler the point of the screw is platinized and comes in contact with a plate also platinized, and soldered to the piece which beats against it, so that perfect contact is as little as possible interfered with by oxidation. In time, however, the platinum burnt by the electric spark does undergo oxidation; and the oxide deposited on its surface checks the passage of the current, as already explained, and weakens the power of the instrument, the play of the trembler being either hindered or altogether stopped. This fault has been remedied by increasing the thickness of the piece of platinum, and by making it (as described of my own instrument) movable, so

that when after working some hours a day for many months, it becomes oxidized, it may be shifted a little to the left or right, and a new place brought into use. Clean also the point of the screw from time to time, by rubbing it with a piece of fine emery paper, to remove the oxide.

Duchenne's small Volta-faradic Instrument, is a reduction of the instrument just described. It has the form of a flat oblong box (fig. 22). When it is open, as in fig. 24, it is seen to be divided into two parts. To the right is placed the induction

Duchenne's small Volta-faradic Instrument.

FIG. 22. FIG. 23.



Duchenne's small Volta-faradic Instrument (closed).

Soft Iron Core.

instrument, properly so called. To the left is the battery in the lower compartment, A, and the electrodes and their conductors are in the upper compartment, B. The induction apparatus is composed of the two superposed coils, the wires of which are of different length and diameter, and of

Duchenne's small Volta-faradic Instrument.

a core formed by a broad band of soft iron, rolled into a helix, as in figure 23, so that it can be placed in the centre of the coils. There is also a commutator, c (all the foregoing portions are concealed in the compartment to the right). There is

FIG. 25.

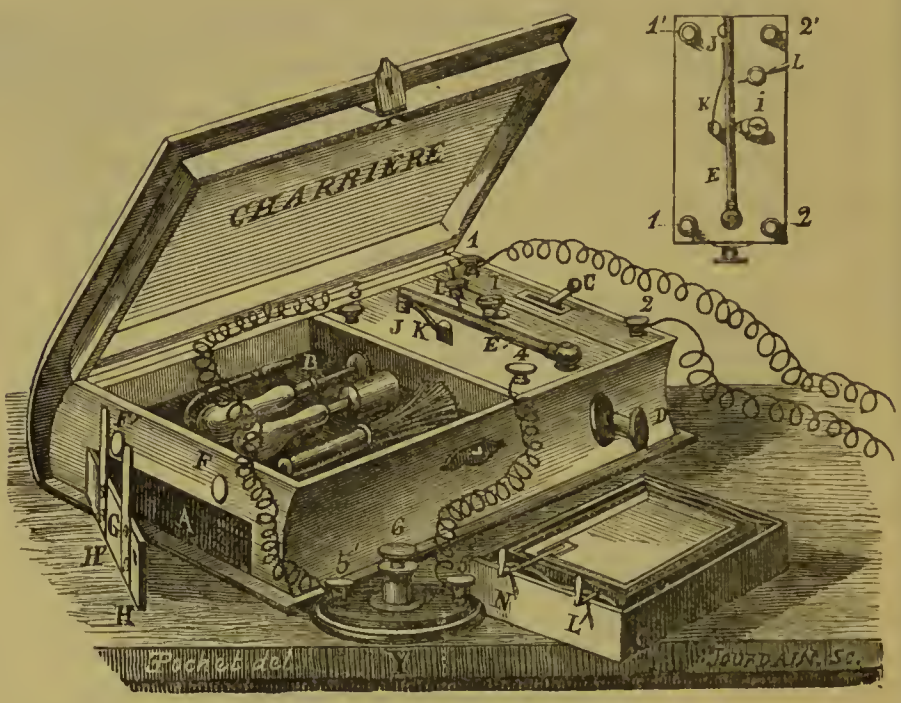


FIG. 24. FIG. 26. FIG. 27.

Fig. 24.—Duchenne's small Volta-faradic Instrument. (Opened).
Fig. 25.—Details of the cover of the compartment to the right.
Fig. 26.—Pedal.
Fig. 27.—Pair of elements with bisulphate of mercury.

a graduator tube, D, a trembler, E, and a rheotome, L, for slow intermissions. A pair of elements with bisulphate of mercury is introduced into the compartment, A. Then if the door, G, of this compartment be closed as in fig. 22, the small platinized

Duchenne's small Volta-faradic Instrument.

plate, L′ (fig. 27), which communicates with the carbon contained in the caoutchouc cell, comes in contact with the spring, H, which rests against the platinized termination, F, of one of the extremities (poles) of the primary coil, while the zinc N, (fig. 27), is brought into communication with the other extremity (pole) of the primary coil, by the spring, H′. If it is wished that the intermissions should be made slowly, the knob, L (fig. 25), must be turned till the line traced upon it is directed transversely. If rapid intermissions are desired, the button, I, must be turned from right to left until the bar, E, pushed forward by a platinized eccentric fixed to the button, is sufficiently near to the temporary magnet, J, which is in contact with the soft iron in the centre of the coil. The approximation is sufficient when the noise of the trembler can be heard. The movements of the trembler must be carefully regulated. Slow intermissions may also be produced with the pedal rheotome, Y (already described with the large instrument). For this purpose its conducting wires must be attached to the knobs, 3 and 4 (fig. 24), and then after having turned the button, I, from left to right, until the bar, E, is in contact with the magnet, J (in this position the battery current is interrupted), the intermissions are to be made with the foot in the manner already described. (By pressing on the knob, 6, fig. 26, the battery current is completed.) The electrode knobs, 1 and

Duchenne's small Volta-faradic Instrument.

2, receive the currents of each coil, and to them are fixed the conducting wires. To these knobs the current either of the primary or secondary coil can be brought by pushing to the left or to the right, as far as it will go, the stem of the commutator of the coils, C. The figures engraved upon the small plate of copper traversed by this stem, point out the side towards which the stem should be pushed in order to bring one or other of the currents to the knobs 1 and 2. The graduation is effected by the tube, D, as in the other instruments. In the intervals between the applications the battery current is interrupted by pushing back the stem of the rheotome, L, until the bar, E, is in contact with the soft iron, J.

The power of this small instrument is very considerable, regard being had to the small size of its coil. This is not only due to the excellent proportions of length and diameter of its wires, and to good manufacture, but also, and chiefly, to the powerful magnetization of its band of soft iron rolled into a helix, which thus offers a considerable extent of surface.

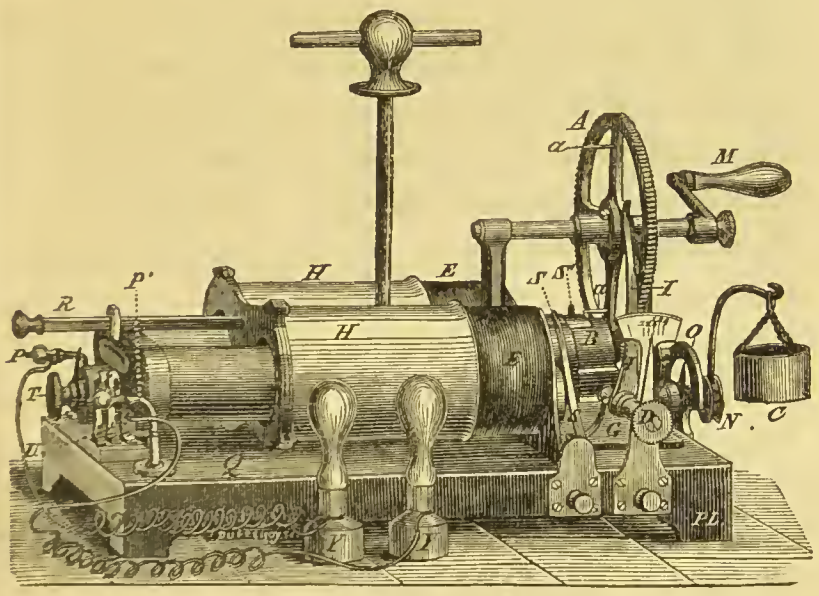
Duchenne's Magneto-faradic Instrument.

Duchenne's Magneto-faradic Instrument.—This consists of a magnet; of an armature set in movement by a peculiar mechanism; of a regulator of the armature that is at once a moderator of the currents and a magnetic tensor; of two coils of copper wire of unequal length and thickness; of a

rheotome; of a regulator of the intermissions; of a graduator of the currents; and of a commutator of the poles (fig. 28). Duchenne's Magneto-faradic Instrument.

The magnet is formed of two parallel cylindrical branches, connected together at one of their extremities by a transverse bar of soft iron. The armature which, by its movement of rotation, pro-

Fig. 28.



Duchenne's Magneto-faradic Instrument.

duces the intermissions of the magnetic current, is traversed in its centre by a horizontal axis terminated at its extremities by a very hard steel point, received in steel sockets, which are screwed into two copper mounts. These mounts are firmly fixed to a square movable plate of copper (G, fig. 28), which rests on the base of the apparatus. Between these

Duchenne's Magneto-faradic Instrument.

two mounts, and at their superior extremity, is fitted a large wheel, A, the axis of which traverses on one side the anterior mount in which it rotates, while the other extremity terminates in a point, and is received in a piece fixed to the posterior mount. The handle, M, which puts the large wheel in motion, can be removed at pleasure. The circumference of this large wheel is divided into sixty-four teeth, which set in action a small wheel of eight teeth, fixed upon the axis of the armature in such a manner that at every revolution of the great wheel the armature turns eight times upon its axis, and consequently produces thirty-two intermissions of the current of induction. As it is possible to make the larger wheel revolve twice in a second, we may obtain sixty-four intermissions in that time. The movable plate, G, is brought near to, or removed from, the magnet by means of a strong screw, N, called the regulator of the armature. This screw turning in a nut fixed to the instrument, acts upon the base of one of the mounts which forms part of the plate, G, which it moves backwards and forwards. In order that the armature may exercise tension upon the magnet, the screw, N, is so turned that the needle is brought to the centre of the arc of a circle, O, which is called the indicator. The superposed coils are similar to those of the Volta-faradic instrument. The end of the one is soldered to the beginning of the other, while the other ends are

Duchenne's Magneto-faradic Instrument.

brought—that of the thick wire to the springs, S, and S′, which produce the intermissions on the reel, B; and that of the fine wire to the right side, U, of the commutator of the coils, T, which conducts the current of the primary coil to the knobs, P and P′, to which are attached the conductors of the rheophores. The spring, s′, gives origin to a conducting wire which proceeds to the left side of the commutator, T. The rheotome is composed of a small wooden reel, B, and of two springs, s and s′. The reel is fixed upon an axis of soft iron. One of the springs, s, in relation with one end of the central wire, rests upon a metallic ring fixed upon the reel. This ring is divided into four teeth, two of which are very short. The second spring, s′, which communicates with the other end of the central wire, is brought into contact with the four, or with the two teeth, by means of the regulating knob of the commutator (not shown in fig. 28), which is fixed to the right of the instrument, and which rotates from right to left, and *vice versâ*. The intermissions are thus regulated:—A piece of copper is fixed to the base of the instrument, to the left of the large wheel. It is traversed by a screw, D, to which is soldered a brass spring, I. By means of the screw, D, the spring, I, can be made to perform a to-and-fro movement, which brings it in contact sometimes with the pins *a*, upon the posterior face of the great wheel, A, and sometimes with the plate, G,

Duchenne's Magneto-faradic Instrument.

which supports the latter. One of the extremities of the inner, and one of the outer, wires of the coil communicate with this plate, G. The brass spring, I, is in relation by a copper wire with the left side, U, of the commutator, T. The currents are graduated by two tubes of copper, H H, which glide over the reels, and can be pulled out or pushed in by the stem, R. When pushed home, the cylinders cover the reels, and the currents are at their minimum of intensity, and at their maximum when the stem is drawn completely out. The commutator of the coils has the same construction as in the Volta-faradic instrument.

In order to put the instrument in action the regulator of the armature, N, must be turned from left to right until the soft iron no longer comes in contact with the magnet during its rotatory movement. If the employment of a rapid current is desired, the regulator of intermissions, D, must be turned from right to left until it reaches its point of arrest. If, on the contrary, slow intermissions are desired, the same indicator, D, must be turned in the opposite direction, and stopped when its needle points to the number of intermissions which it is desired to obtain for each revolution of the large wheel. The handle, turned from left to right, should always be moved very quietly, making perhaps two revolutions in a second. In order to graduate the currents, it is sufficient to remember that when the

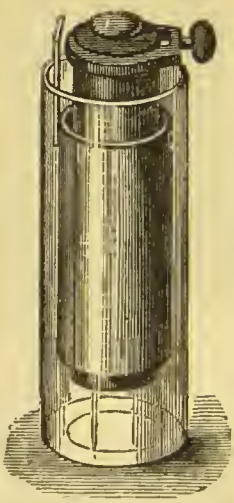
stem, R, is pushed home, the current is at its minimum. If still more feeble doses are required, the armature must be moved further away from the magnet by turning the regulator, N, from left to right. The knob, T, of the commutator of the coils must be turned from right to left, when it is wished to bring the currents of the primary coil to the knobs, P and P′. On the contrary, the knob, T, is turned from left to right, to get the current of the secondary coil.

Duchenne's Magneto-faradic Instrument.

Stöhrer's Induction Instrument.—The battery of this instrument consists of carbon and zinc, without an earthenware cell. The carbon (fig. 29), hollow within, filled with sand, and closed by a glass stopper, serves for the reception of a concentrated solution of chromic acid in water. Of this solution 10 or 12 drops should be added whenever the battery is re-charged. The zinc surrounds the carbon, but is kept from contact by glass insulating buttons. These elements are placed in a circular glass cell, which serves for the reception of diluted sulphuric acid (one part acid to seven parts water). This cell is so arranged in the completed apparatus, that it can be moved vertically up and down, and

Stöhrer's Induction Instrument.

FIG. 29.

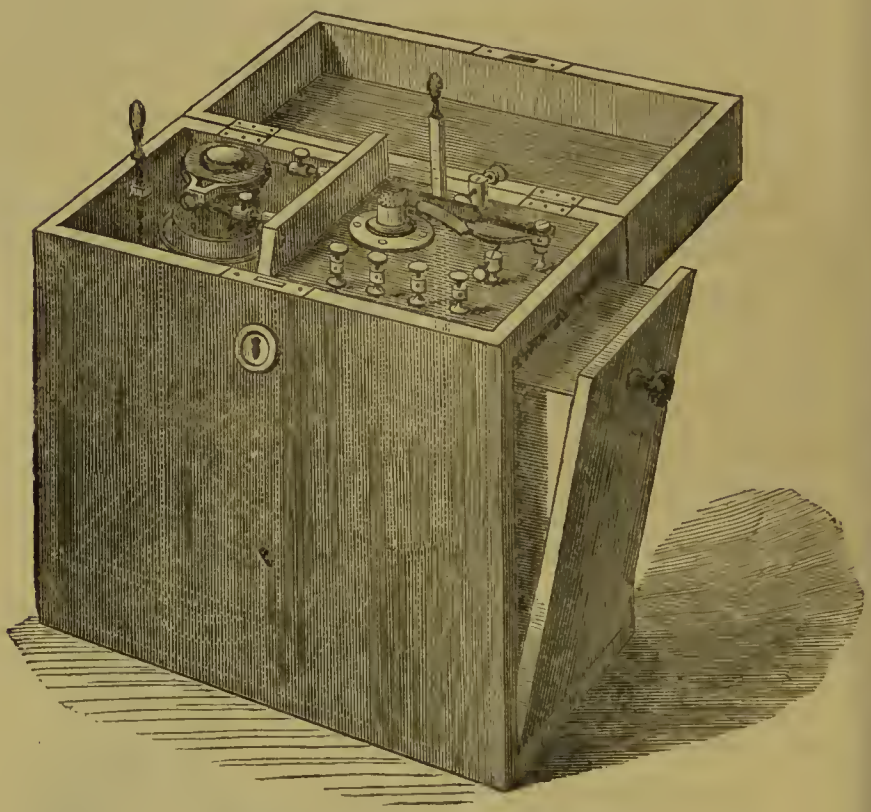


Stöhrer's Battery.

Stöhrer's Induction Instrument.

can be fixed at any point. By this arrangement the acid can be brought into contact with the whole, or with part of the zinc and carbon, or by shutting down the glass, can be excluded from them altogether. In the latter case, the acid will only

Fig. 30.



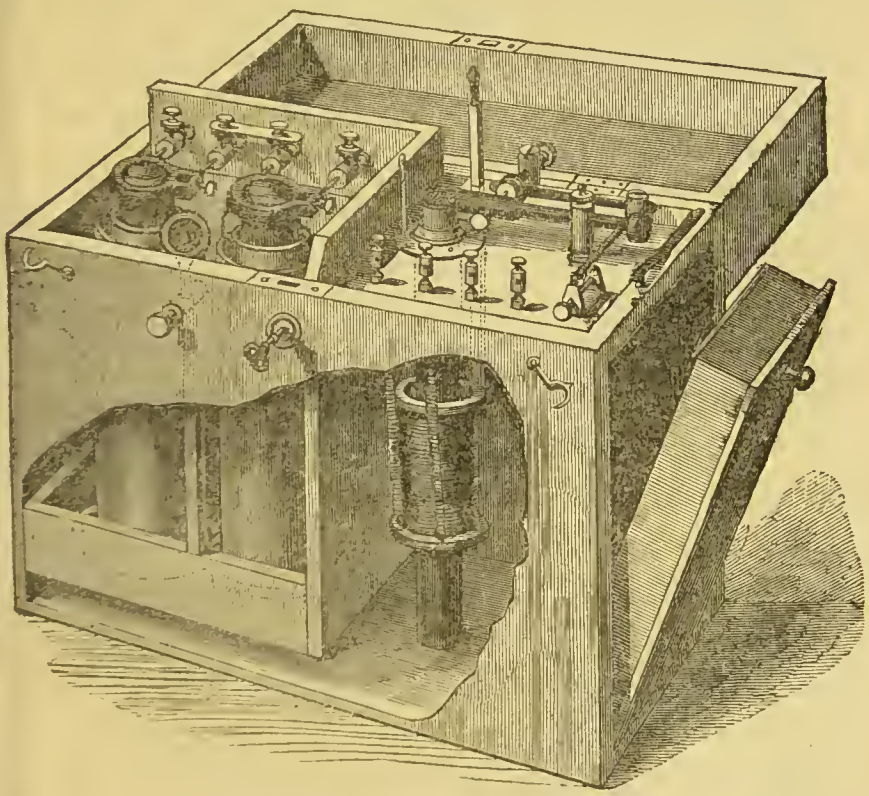
Stöhrer's smaller Induction Instrument.

fill the lower third of the glass. The advantages arising from being able to remove the elements at once, and without difficulty, from the exciting fluid, and from the facility with which they may be brought into action, are obvious.

Stöhrer constructs a smaller (fig. 30), and a larger (fig. 31) instrument. The battery of the former is constituted by a single cell; of the latter, by two cells, which may, however, be arranged either as two pairs, or as a single pair of elements.

Stöhrer's Induction Instrument.

Fig. 31.



Stöhrer's larger Induction Instrument.

Both possess a primary and a secondary coil, the currents of each of which can be made use of separately; and in both the currents have a definite direction, positive electricity being set free at one terminal, and negative at the other, of each of the

Stöhrer's Induction Instrument.

coils. The terminal from which the positive current proceeds may be ascertained easily by the decomposition of iodide of potassium. The larger instrument differs from the smaller in having a much greater range of power, more thorough means of graduating the currents, and a more elaborate arrangement of the interrupting hammer. With practice, however, the force and rate of interruption of the smaller instrument may be regulated with much nicety. To neither instrument is a water graduator attached; but if needed for any special nicety of application, one can readily be added, and it would be best carried loose in the drawer for accessories, to be attached only when required. Graduation of the strength of the currents is effected by the arrangement of the coils. The primary coil is fixed upon a pedestal; the secondary is movable, and is brought into and placed out of action by being lifted over or thrust away from the primary. The degree of action in the secondary coil is proportionate to the extent to which it is brought under the influence of the primary. The action of the primary coil is regulated in the smaller instrument by the extent to which it is masked by the secondary coil—the latter acting upon it as a metallic sheath would do. In the larger apparatus a special copper sheath is provided for the graduation of the current of the primary coil. It is to be regretted that a similar arrange-

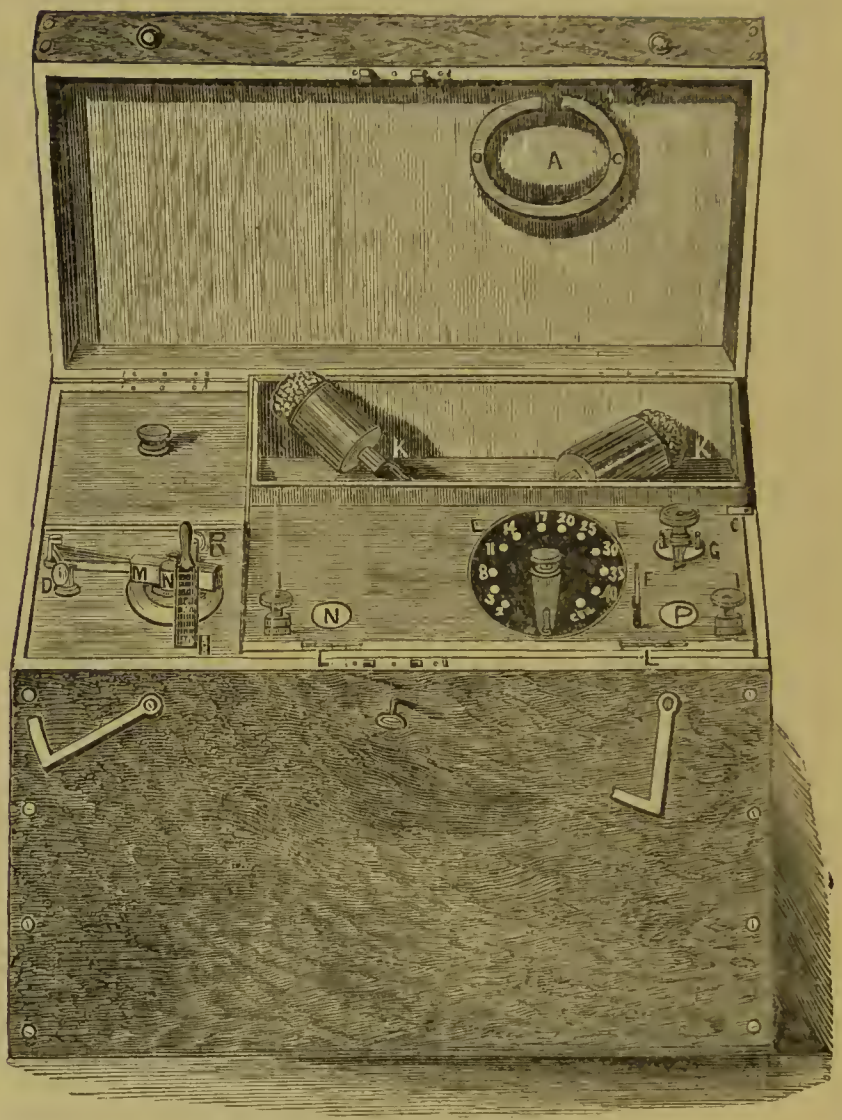
ment has not been adopted in the smaller instrument.

The Tibbits Combined Hospital Battery.—This instrument (fig. 32) consists of 40 or 50 voltaic cells and an induction coil and battery, and it is so arranged that the current from either coil or voltaic cells is brought to the same terminals, thus avoiding the trouble of constantly changing the conductors, a point of the greatest possible convenience when examining patients for diagnostic purposes by both forms of electricity, either in succession or alternately. In this instrument there are combined in one case the essential parts of my voltaic battery (page 16) and induction battery (page 31), and the reader is referred to the description of those instruments for details of its construction and use. The dial, E, fig. 32, differs from that figured at page 19 only in being furnished with an additional stud lettered "*Coil.*" When the needle points to this stud the current from the faradic coil is brought into action, and when it points to the numbered studs, the cells numbered thereon as in the voltaic instrument. When the needle points to "0" both currents are shut off. The more common form of the combined battery is represented in fig. 32, where it is fixed in a square mahogany case, the voltaic cells being all on the same level; and this, as simplest in construction, is most to be recommended where patients are usually brought to the operator for treatment.

The Tibbits Combined Hospital Battery.

The Tibbits Combined Hospital Battery.

FIG. 32.



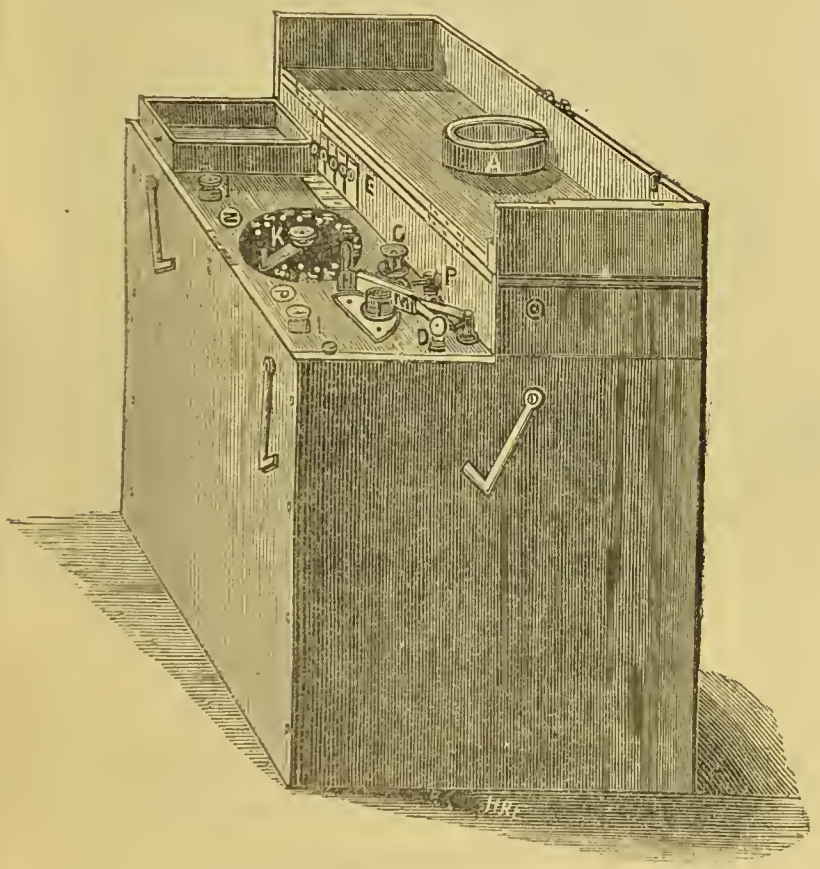
The Tibbits Combined Hospital Battery.*

* A. Guard block.
C. Bolt.
D. Screw regulating spring of hammer.
E. Dial.
F. Commutator of poles.
G. Key.
H. Graduator of induction coil.
I, I. Binding screws.
K. Tray for holding accessories.
L, L. Hinges of element board.
M. Hammer.
N. Electro-magnet.
R. Screw regulating needle.

The Tibbits Combined Portable Battery.

But a more portable arrangement, especially convenient for use when visiting patients at their own homes, is seen in figs. 33 and 34, where, by

Fig. 33.



The Tibbits Combined Portable Battery.*

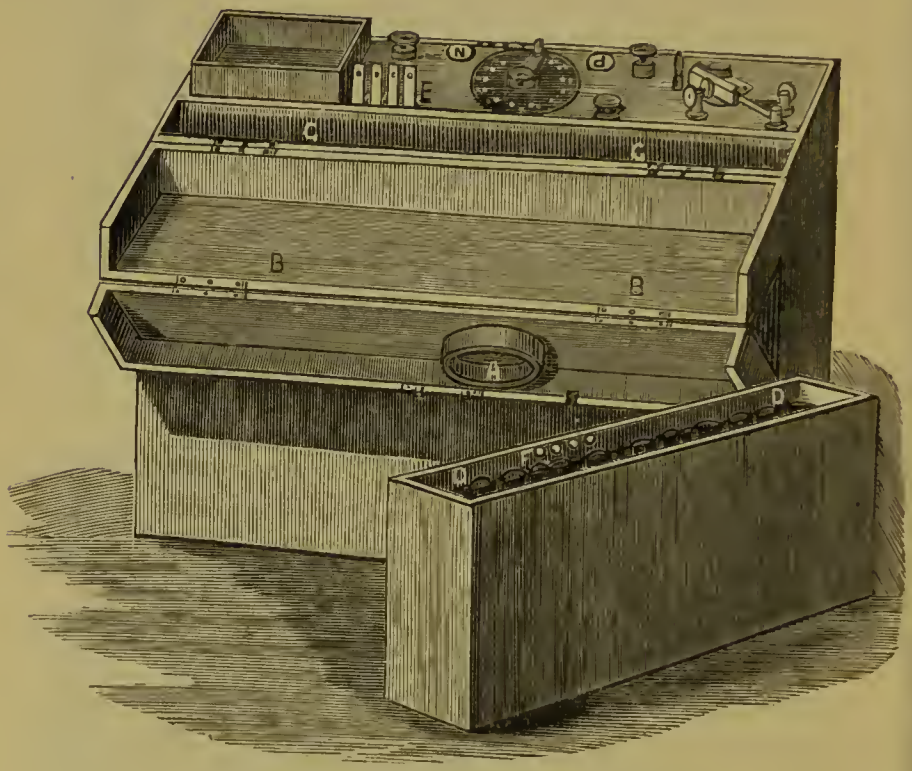
* In fig. 33 the instrument is seen with the lid open, ready for use.

A. Guard.
D. Spring of hammer.
E. Connecting screws.
F. Electro-magnet.
G. Interrupter.
H. Graduator of coil.
I, I. Terminals.
K. Regulating dial.
M. Vibrating hammer.
P. Screw regulating needle.

The Tibbits Combined Portable Battery.

packing the cells in tiers, the maximum of power has been united with the minimum of space, so that

Fig. 34.



The Tibbits Combined Portable Battery.*

this latter instrument is hardly more bulky than the voltaic battery alone. It measures only 14 inches long, 10 wide, and 10 high.

* Fig. 34 shows the packing of the cells in tiers, the lid, which folds upon itself by a second pair of hinges, B, B, having been thrown back to expose the tray, D, which, with its contained cells, has been lifted out from the space, G, G. This tray is held in position, and connection with its cells made by four brass screws, inserted through four springs, E, the screw-holes, F, being also seen in the tray, D. These screws, which have been removed in fig. 32, are seen *in situ* in E, fig. 33. The other details are similar to those of the Hospital Battery, fig. 32.

The Accessories of the Apparatus.

Accessories of the Apparatus.

The first necessary accessory is a conducting cord or wire between the poles of the instrument and the sponge-holders, electrodes, or, as they are generally called, rheophores (current carriers). I have had endless trouble with conducting cords, which are always liable to get out of order and cause interruptions in the current. I strongly advise that nothing should be used but very thin copper wire coated with gutta-percha in the same way as that known as "telegraph wire." This is perfectly insulated, sufficiently pliable for all practical purposes; it is inexpensive, it does not kink, it will fit any sort of rheophore, and if the end breaks all that is necessary is to scrape off with a pocket-knife the coating for about a couple of inches from the broken end. For use when the rheophores remain immovable during the whole time of the application, the ordinary telegraph wire is more convenient, and from its much greater diameter will wear much longer, but it is not sufficiently flexible for other purposes. The other accessories will be described with their special uses in the next chapter.

The Conducting Wires.

CHAPTER II.

THE APPLICATION OF ELECTRICITY.

The Application of Electricity.

THE scientific electro-therapeutic application of electricity is the growth of the last thirty years. Prior to this date the difficulty of obtaining apparatus adapted for the purpose and the consequent inconvenience of the whole proceeding, seems to have stopped all inquirers at the very threshold. To Duchenne (who has been aptly called the "father of electro-therapeutics") may fairly be ascribed the birth of medical electricity as a branch of therapeutics, and his writings undoubtedly impelled to its study some of the most painstaking physicians, especially in Germany. Before Duchenne no one had attempted any local application of electricity that could be properly so called. The only effort towards this end had been that of Sarlandière in 1825, who conceived the ingenious idea of using acupuncture in order to direct and limit the power of electricity within certain nerves or muscles. The pain of this application, especially when a large number of needles were inserted, and many other disadvantages, precluded it from being adopted in practice. But it appears to have sug-

gested to Duchenne that in some way it might be possible to arrest electricity in the skin without stimulating the subjacent organs; or, on the contrary, to cause it to penetrate the skin without influencing it, and concentrate its power on the deeply-seated muscles or nerves. The result of his experiments was entirely successful, and we owe to him the fundamental principles of all methods of localized electrization. He applied to the dry skin the dry metallic conductors of an induction instrument in action. Sparks and crackling were produced, but no physiological phenomena. *The electricity did not penetrate the skin.* He replaced the dry conductors by well-moistened sponges. The current produced neither sparks nor crackling, but very variable phenomena of contractility or sensibility, *according as it acted upon a muscle, a nerve, or an osseous surface.** Duchenne distinguished between "direct muscular electrization," the production of contraction by placing the rheophores on the muscle itself, and "indirect muscular electrization," in which contraction is produced by exciting the nerve trunk or branches. By the German school these have been also termed "intra-muscular" and "extra-muscular" electrization; but before entering upon this part of the subject, it will be

* See Duchenne (de Boulogne) "On Localized Electrization and its applications to Pathology and Therapeutics." (English edition.) Part I., pp. 38–44. London: Churchill.

convenient to consider the more general methods of application, beginning with Franklinization.

Franklinization.

Franklinization.

To administer Franklinism, we insulate the patient by letting him stand upon a glass-legged stool, sit upon a chair placed on a platform with glass supports, or recline upon a couch the four legs of which are insulated by being inserted into large glass jars. Then we connect him by a brass chain held in his hand with the conductor of a friction machine in action, and thus make him as it were a part of it. The accumulated electricity passes to him, and he becomes in common with the conductor *charged*. If the air were perfectly dry he would continue in this charged condition, but owing to its contained moisture the electricity rapidly leaves him, and to maintain the charge it is necessary that the plate of the machine should be kept in constant rotation. Indeed the escape of electricity is so rapid that to get good action we must have a fire in the room, and before use rub well the plate, the insulating supports, the legs of the stool, and all the glass parts of the apparatus with a warm and dry piece of flannel. This is of importance, and however dry the day, should as a rule never be neglected. The patient charged from the prime conductor, is said to be taking an *electro-positive bath;* but if he be connected by the chain with the cushions of the

(*a*) Electro-positive Bath.

machine, instead of with its conductor, he would be charged not with positive but with negative electricity and—be taking an *electro-negative bath*. The whole surface of the body becomes charged with electricity, which escapes from all points of the skin. If it is desired to localize somewhat this escape along the course of certain nerve branches, or otherwise, but to avoid shock, a brush may be slowly passed by the operator almost, but not quite, in contact with the skin. A series of rapid and successive reunions of the electricity with each bristle of the brush takes place, generating a current of cold air perceptible to the patient. I habitually use for this application an ordinary clothes-brush. If while in connection with the prime conductor any object (the knuckles will do) is brought sufficiently near to him for his contained electricity to overcome the resistance of the intervening stratum of air, he is "*discharged*" with a spark. This is *Franklinization by sparks*, and is accompanied by a certain slight amount of "shock." If it be desired to render this shock painful, electricity of a degree of tension only to be obtained from a sufficiently charged Leyden jar or jars must be made use of, and this may be rendered so powerful that the whole limb, or even the whole body, is as it were struck by lightning. This is *Franklinization by the Leyden jar*. To apply this form of Franklinization, well warm the inside and outside

(*b*) Electro-negative Bath.

(*c*) Franklinization by Sparks.

(*d*) Franklinization by the Leyden Jar.

(*d*) Franklinization by the Leyden Jar.

of the jar, and place it with its knob, communicating by the rod with its inner coating, sufficiently near to the conductor of the machine in action to draw sparks from it. Also connect by a hook and brass chain, or preferably a length of insulated wire, the same knob with one of the excitors, insulated by a glass handle, and the outer coating of the jar by a second wire, looped round it, with a second insulated excitor, then have the machine rotated until the number of sparks required have passed into the jar, which is discharged by applying the extremities of the two excitors to the two points of the body through which it is desired that the electricity should pass.

If necessary, two or more jars may be combined by connecting their outer and inner coatings, but it is very rarely required to use more than one, provided it be of adequate size, say of about forty ounces.

Voltaization.

Voltaization.

(*a*) Constant.

Voltaization is administered under two forms, the "*constant*" and the "*interrupted*" voltaic current. In the "constant" current the conductors are maintained immovable upon the skin; or the feet or hands, as the case may be, are immersed in tepid salt water, with which the conducting wires of the battery are in contact, and the current is allowed to pass during the time required. The tension of voltaic electricity is so low that salt is required

to render the water a good conductor. In the "interrupted voltaic current" the current is INTERRUPTED by gliding over the skin one or both of the rheophores; or the feet or hands may be placed in salt water with one pole, and the other pole may alone be movable. There is an application of *positive* voltaic electricity, originated by Dr. Radcliffe, the therapeutics of which will be discussed hereafter, in which the patient and the battery must both be insulated, the passage of the current quite constant, and a wire, which Dr. Radcliffe terms a "ground wire," carried from the negative pole of the battery, or from the negative rheophore, to the earth. This wire may conveniently be attached to a chandelier or gas-pipe, which always gives a direct metallic conduction to the ground. With careful insulation, the negative electricity passes away by this wire, and while the current circulates the patient continues "*charged*" with positive electricity—a condition analogous to the electro-positive bath described under Franklinization. A sheet of gutta-percha, about four feet square by half an inch thick, will answer admirably to insulate the patient and the accessories.

(*b*) Interrupted.

Dr. Radcliffe's Positive Charge.

Localized Voltaization and Localized Faradization.

Localized Electrization.

Localized voltaization and localized faradization require the same operative procedures, and in describing them I shall make use of the general term electrization.

Direct Muscular Electrization.

Direct Muscular Electrization.

In direct muscular electrization the muscular tissue is directly excited by placing well moistened rheophores on points of the skin corresponding to the muscle it is desired to act upon. For the muscles of the trunk which have a large surface, it

Rheophores.

is most convenient to use well moistened sponges contained in cylinders, or metallic disks covered with wet leather and having conveniently shaped handles. Fig. 35 is one of Duchenne's sponge-holders. All others that I have seen are much too long in the cylinder, and the reader in ordering would do well to give the dimensions, about $1\frac{1}{2}$ by $1\frac{1}{8}$ inches, and to see that the handles are hollowed out as in the figure. It is astonishing how difficult it is to get an instrument maker to do this, and to have it properly done makes a material difference in the ease with which they can be used, lying comfortably between the fingers, as in fig. 37, which shows the most convenient method of holding two rheophores in the same hand. Fig. 36 is a disk rheophore, a metallic button covered with

washleather. This is by far the most generally useful rheophore; and by using the edge it may be made to answer in the majority of cases for fig. 39.

Different kinds of Rheophores.

Fig. 35.



Sponge-holder with insulating handle.

Fig. 36.



Metallic rheophore with disk.

Fig. 37.



Method of holding rheophores.

It also has the advantage over the sponge of allowing firm pressure to be made without the inconvenience of water being squeezed out. Fig. 36, *a*,

Different kinds of Rheophores.

shows the usual method of connecting the conducting cord with the rheophore, which is seen *in situ*, received into the screw socket of the rheophore in *a'*. The cord is very apt to get frayed where it passes through the eyelet hole, which spoils it at

Fig. 39.

Fig. 38.

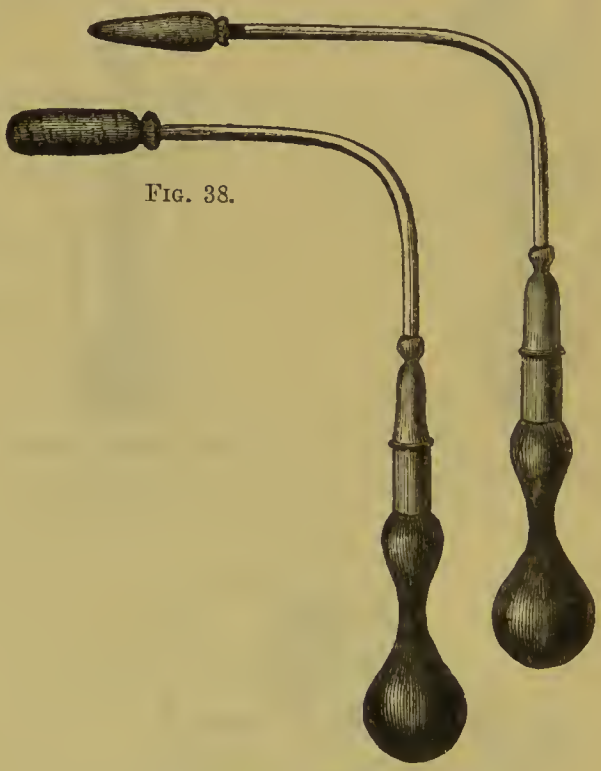


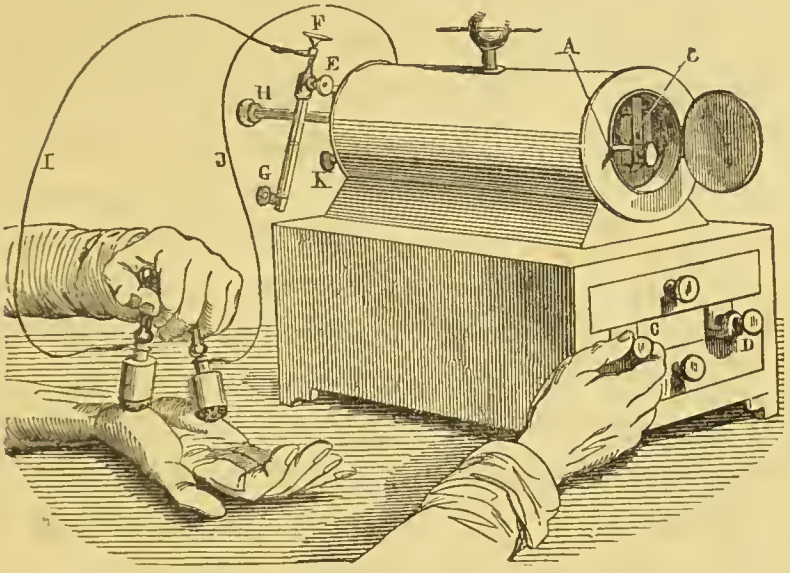
Fig. 38. Olivary metallic rheophore.
Fig. 39. Conical metallic rheophore.

once. The wire which has been previously recommended is not open to this objection, and this is not the least of its advantages. Figs. 38 and 39 are other varieties of rheophore, fitted chiefly for application to very small muscles, such as the interossei,

and some of those of the face. Fig. 40 shows Duchenne's method of holding two rheophores. The application is being made to the muscles of the

Different kinds of Rheophores.

Fig. 40.



Duchenne's Method of holding Sponge-holders in a single hand.

hypothenar eminence with one hand, while the other hand is employed about the instrument. In fig. 41 the conical rheophores are in like manner applied to the face. As it is requisite to administer to a muscle a dose of electricity proportionate to its degree of excitability, the operator should, whenever possible, have one hand at liberty. In direct electrization the rheophores must always be applied over the fleshy body of the muscle and not over its tendons, and in order to electrize it completely *they should cover the whole of its surface, and*

Rule to be observed in Direct Muscular Electrization.

when they are not large enough to do this, they must be applied in succession to all points of its surface. The thicker the substance of the muscle the more intense must be the current, because a weak current will only produce excitation of the superficial layers. It is very necessary in practice not to lose sight for a moment of this fundamental axiom, which one is very apt to do, and so unequally to electrize the muscle; and it is a good rule to promenade, as it were, the two rheophores, held as in fig. 37 or fig. 40, in lines along and across the muscle or group of muscles; keeping them stationary on *every point of the muscle* for about thirty seconds, and letting the entire application vary from five to fifteen minutes, according to therapeutic requirements. In direct electrization with the interrupted voltaic current it is more usual to maintain one rheophore stationary, and to glide the other in lines from the first. As a rule, the positive electrode is the stationary, and the negative the movable one, but this order can be reversed if necessary.

Fig. 41.



Duchenne's method of holding conical rheophores.

Indirect Muscular Electrization.

Indirect Muscular Electrization.

When muscular contraction is produced by acting upon the special nerve trunk and branches instead of by placing the rheophores upon the muscle itself, the procedure is termed *indirect muscular electrization*. For its successful practice a detailed knowledge of anatomical relations is necessary, especially of the position of the muscles and of their nerves with regard to one another, to the sensitive nerves and to the surface of the body. It is common to find variations in the course of the nerves, and in the mode of their distribution among the muscles, so that the points most suitable for their excitation can only be pointed out approximately.

It is convenient to place a broad conductor, such as a sponge contained in a cylinder (fig. 35), upon some little sensitive part of the body, such as the sternum, and to apply a fine-pointed conductor, such as the conical rheophore (fig. 39) to the most superficial point of the nerve it is desired to act upon.

The following figures (figs. 43 to 60) are copied from photographs by Ziemssen, and the motor points indicated by them were obtained as follows:—One electrode, as small as a knitting-needle, its point covered with a layer of the finest sponge, was used for the excitation of the nerves; while the other electrode, covered with a thick cushion of

Indirect Muscular Electrization.

sponge, was used to connect the battery with the sternum. Marks were made upon the skin of the person experimented upon with coloured chalk, and after a sufficient number of trials with nitrate of silver, photographs of the parts thus marked were taken, and afterwards transferred to the wood blocks. These figures may therefore claim to be true to nature, although they may not be absolutely correct for every individual. Ziemssen verified their approximate exactitude by following the course of the nerves very accurately in the dissecting-room, and observing their points of entrance into, and their course within, their muscles, with constant reference to the surface of the body; but he was not completely satisfied until he had determined the motor points with the faradaic current, and marked them upon the skin in corpses immediately after death, and before the irritability to electricity had disappeared, and submitted these points to the scalpel. The results of the three methods coincided perfectly. The electrodes he used are shown in fig. 42.

Fig. 42.



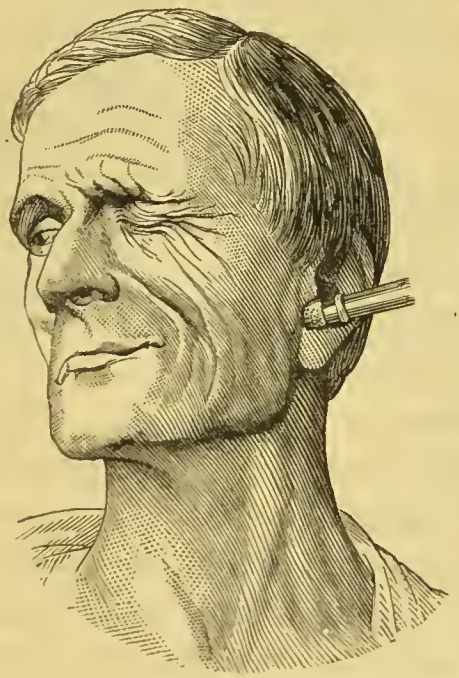
Ziemssen's Electrodes.

The Head.

The Facial Nerve.

The trunk of the facial nerve may be excited from the external auditory meatus by pressing a thin electrode against its lower wall. Energetic contractions will be produced in all the muscles that the nerve supplies. With less pain in thin persons it may be found immediately after it leaves the stylo-mastoid foramen. Press the rheophore strongly, just below the concha, between the

FIG. 43.



Facial Nerve.

mastoid and condyloid processes. The energetic contraction of all the muscles it supplies is well seen in fig. 43. The branches from the facial to

Branches to Stylo-hyoid and Digastric.

the stylo-hyoid and digastric muscles may be excited in thin men by pressing the electrode deeply behind the condyloid process of the lower jaw. Their contraction is shown by movements of the os hyoides outwards, backwards, and upwards. In the parotid gland the single large branches of the facial are easily found, and produce contraction in definite groups of muscles corresponding to the ordinary divisions of the nerve; those branches which leave the parotid, and rest more or less closely on the bone, are easily excited, but not those that are imbedded in soft parts, especially the buccal branches. The frontal muscle may be thrown into contraction from beyond its own limits, since the branch of the facial by which it is supplied, before dividing for its final distribution, courses for some distance from the temple to the zygoma. To produce its complete contraction, its symmetrical nerves must be simultaneously excited by two electrodes, as in fig. 44. The orbicularis palpebrarum may be excited either upon the zygoma or beyond it towards the parotid gland: close to the orbital margin the nerve commonly divides into a superior and inferior branch supplying the upper and lower halves of the muscle. Excitation of the trunk before it divides closes the eye firmly. In the neighbourhood of the eye it is necessary to be very circumspect with the strength of the current (especially the voltaic). Duchenne

Branch to Frontal Muscle.

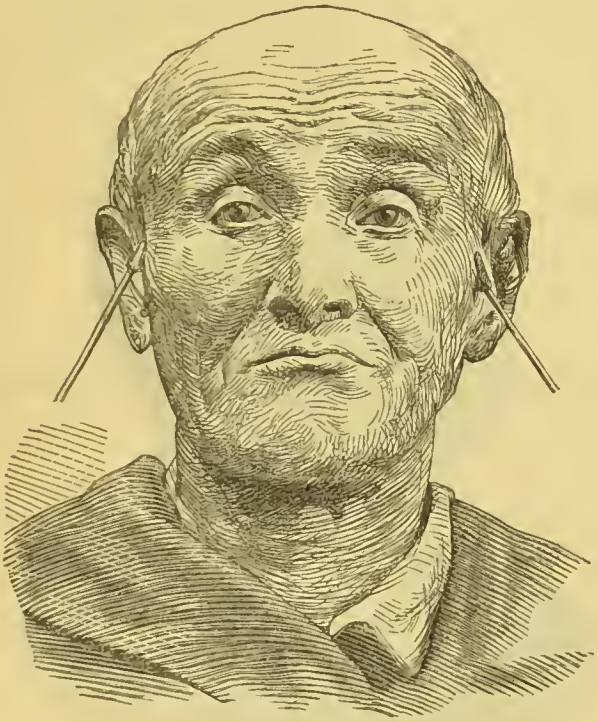
Branch to Orbicularis Palpebrarum.

The Facial Nerve.

quotes a case of blindness caused by too powerful an application of electricity, but weak faradization

The Facial Nerve.

Fig. 44.



Frontal Muscle.

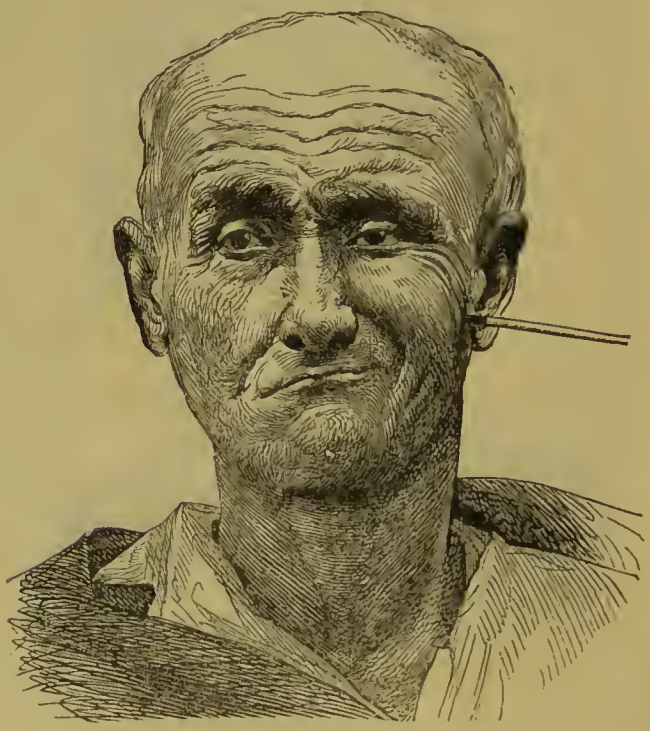
may be applied without injury even upon the conjunctiva, although the application is very painful. The nerve of the zygomaticus major may be excited quite close to the origin of the muscle at the inferior and external edge of the zygoma, and the certain bony support afforded for the pressure of the electrode makes its excitation unusually certain—more so than that of any other facial muscle. By its contraction (fig. 45) the angle of

Branch to Zygomaticus.

Branch to Zygomaticus.

the mouth and the contiguous portion of the upper lip are drawn upwards and outwards, and the skin of the cheek is thrown into deep folds.

FIG. 45.



Zygomaticus Major.

Branch to Orbicularis Oris.

The orbicularis oris: The twigs to this circular muscle enter it at four points on each side of the face, one for the upper and one for the lower lip, and to produce complete contraction, four electrodes would be required. The twigs must be isolated in close vicinity to the external border of the muscle.

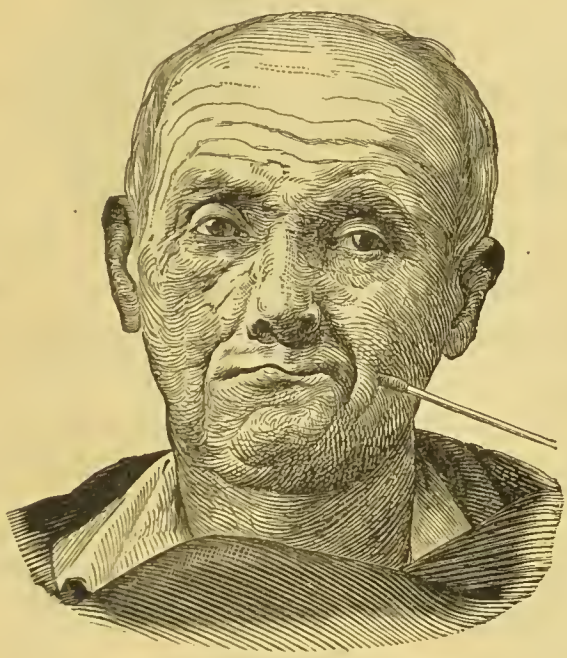
The Buccinator.

The buccinator: Its nerves have a variable course,

and are best sought at the inner margin of the masseter (fig. 46). The cheek becomes tightly contracted and pressed upon the teeth. The masseter and temporal muscles, on account of the

The Buccinator.

Fig. 46.



Buccinator.

deep entrance of their motor nerves, can only be thrown into contraction by direct muscular excitation, since the belly of the muscle intervenes between the electrode and the entrance and course of the nerve. Of the nerves of the cavity of the mouth, those of the tongue are the most accessible. Excited on either side, the tongue becomes contracted and bowed towards that side. If when

Nerves of the Cavity of the Mouth.

Nerves of the Cavity of the Mouth.

drawn upwards and backwards, its under surface is excited, it will be forcibly protruded. The velum can be only slightly distorted by lateral excitation, but its contraction and displacement backwards and upwards are easily produced by feeble currents.

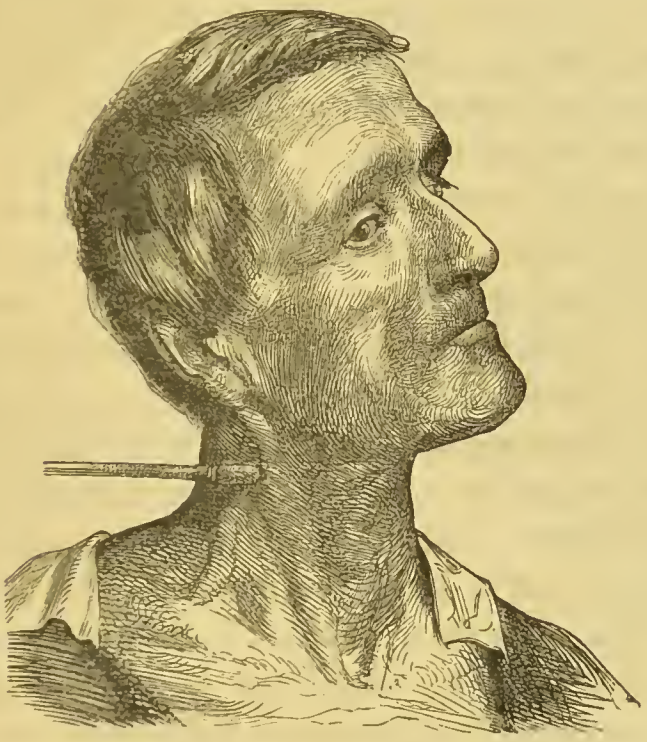
The Neck.

Nerve of Willis.

The accessory nerve of Willis, external branch, may always be isolated with facility. After passing out behind the sterno-mastoid, and giving its branch to that muscle, its course is superficial to the trapezius. Above the origin of the branch to the sterno-mastoid it may be reached without difficulty by pressing the electrode strongly into the middle of the belly of the upper half of that muscle; or if this does not succeed, by placing the electrode behind the belly of the muscle, and pressing it upwards and inwards, as seen in fig. 47. Simultaneous contraction of the sterno-mastoid and trapezius result; the cervical spine is bowed, the lower jaw pushed forwards, and the head rotated so as to turn the face away from the side that is irritated; the shoulder is strongly elevated and drawn backwards and inwards. The sterno-mastoid alone may be thrown into strong contraction by its branch from the accessories. Direct the electrode a little below the point for the main trunk of the nerve. Irritation of the accessories close to the margin of the trapezius will throw this

muscle into isolated contraction with either elevation of the shoulder backwards and upwards, with Nerve of Willis.

Fig. 47.



Sterno-mastoid.

drawing up of scapula, or depression of head backwards and outwards, or both movements, according as the head or scapula is fixed by antagonist muscles. The hypoglossal nerve is accessible close above the great cornu of the hyoid bone in front of the hypoglossus muscle. The usual result is elevation of the whole tongue against the hard palate, with simultaneous action of the hypoglossus and other muscles. Hypoglossal Nerve.

Rhythmical Electrization of the Phrenic Nerves, and their accessories.

Electrization of Phrenic Nerves.

The phrenic nerve may be discovered at the outer margin of the sterno-mastoid, in front of the scalenus anticus, and above the omo-hyoid. It must not be sought too deeply, but the electrode must be pressed inwards against the outer margin of the sterno-mastoid. If the point of the electrode be carried too high, it will encounter the fifth cervical nerve, which forms an acute angle with the phrenic. The electrode must not be carried above the middle of the sterno-mastoid, but kept near the omo-hyoid, the exact position of which is very easily found by faradization. The electrodes must be pressed in strongly, and in an oblique direction from without inwards. The proof that the phrenic is reached is afforded by rapid contraction of the diaphragm, arching forwards of the trunk, and forcible rushing of air through the glottis into the trachea, with a noise like the sobbing of a crying child. A powerful current is required, and its strength must be gradually increased until decided action of the diaphragm is obtained. This excitation, whether of one nerve or both, is unattended by danger, and generally produces no pain. In artificial respiration one electrode should be placed over the phrenic at the point where the omo-hyoid lies at the outer border of the sterno-mastoid, and the other upon

the side of the thorax in the seventh intercostal space, and pressed in as deeply as possible towards the diaphragm. Faradization in this manner should be applied to the right and left sides alternately, and the circuit maintained unbroken for about the period of a deep inspiration. Or the two phrenics may be simultaneously excited. Take the disk rheophores (fig. 36), place them on both sides of the neck over the lower end of the scalenus anticus at the outer margin of the sterno-mastoid, direct them somewhat inwards, and press firmly. We may in this way be certain not only to excite the phrenic nerves, but also, from the extent of bearing of the electrodes, to produce contraction of the inspiratory muscles supplied by nerves which traverse the path of the current, as well as directly to excite the scalenus anticus and sterno-mastoid.

Electrization of Phrenic Nerves.

The large electrodes are recommended for these reasons as well as for the greater ease with which we are enabled to hit the phrenics. It is also necessary that the head, shoulders, and arms of the patient should be fixed by assistants, in order that the auxiliary muscles of inspiration, especially the serratus anticus major, and the pectorals, should have fixed points from which they may energetically act upon the chest; and sometimes, in order to control disturbing movements of the upper extremities, caused by accidental irritation of the motor twigs proceeding to them from the brachial plexus.

Electrization of Phrenic Nerves.

The length of each excitation should be that of a quiet, deep inspiration, that is, about three seconds. The expiration is best accomplished by an assistant, who makes strong and extensive pressure upon the abdomen in the direction from below upwards. It is necessary to make a pause after a number of excitations, and to observe whether spontaneous respiration will occur. The duration of such a pause must be governed by the character of the natural respiratory movements. Care must be taken to maintain the conductors in position and well pressed down.

The Brachial Plexus.

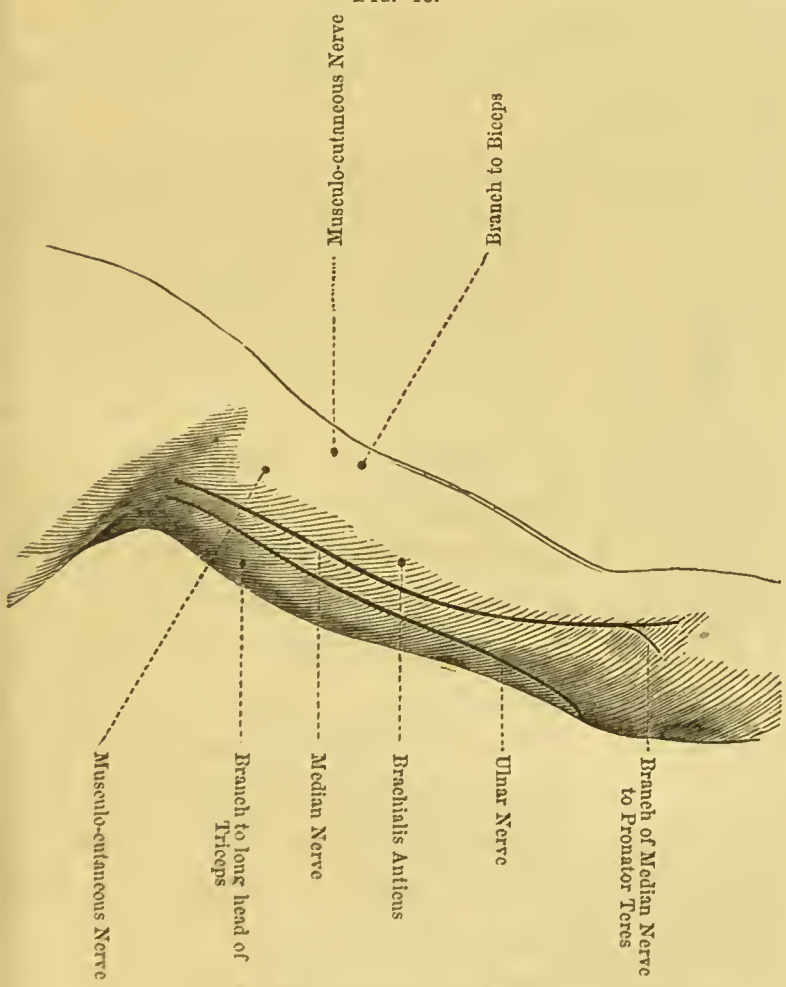
The motor nerves proceeding to the shoulder and thorax from the supra-clavicular portion of the brachial plexus may all be excited under favourable circumstances without the chief trunks of the plexus being involved. In all cases, exact anatomical knowledge, together with experience in faradization and in the use of fine electrodes, is necessary. The trunks of the supra-clavicular part of the brachial plexus are of no avail for the excitation of individual muscles, since the irritation of every single trunk causes the contraction of whole groups of muscles which have generally no harmony of action, but which receive nerve fibrils from the same stem. Whenever the therapeutic value of indirect electrization does not depend upon the excitation of individual muscles, and when the unavoidably painful irritation of the sensitive fibres is unimportant, as, for example, in paralysis of the whole arm, electriza-

tion of the brachial plexus, on account of its superficial position, is especially adapted for an unpractised operator. The Brachial Plexus.

The Superior Extremity.

In fig. 48 the motor points of the anterior surface of the left arm are shown.

FIG. 48.



Anterior Surface of Left Arm.

Axillary and Musculo-spiral Nerves.

The axillary and musculo-spiral nerves are both included in the posterior cord of the brachial plexus, so that by its excitation energetic contraction of the deltoid results, as well as of the muscles supplied by the musculo-spiral nerve.

The Musculo-cutaneous Nerve.

The musculo-cutaneous nerve, after its passage through the coraco-brachialis, is found in the interval between that muscle and the biceps, or further outwards between the two heads of the biceps. Strong flexion of the forearm is the result of its excitation.

The Median Nerve.

The median nerve is accessible along the whole of the furrow by the inner side of the biceps, but with more certainty over the lower third of the humerus, after it has crossed to the inner side of the brachial artery, where it can be compressed against the bone. The result is pain in its sensitive branches distributed to the thumb, fingers, and palmar surface of the forearm, and contraction of the pronator teres, pronator quadratus, flexor carpi radialis, palmaris longus, flexor digitorum sublimis and profundus, as well as of the muscles of the ball of the thumb, and of the three first lumbricales. The effects, therefore, are strong pronation of the forearm, bending of the hand towards the

Fig. 49.



Median Nerve.

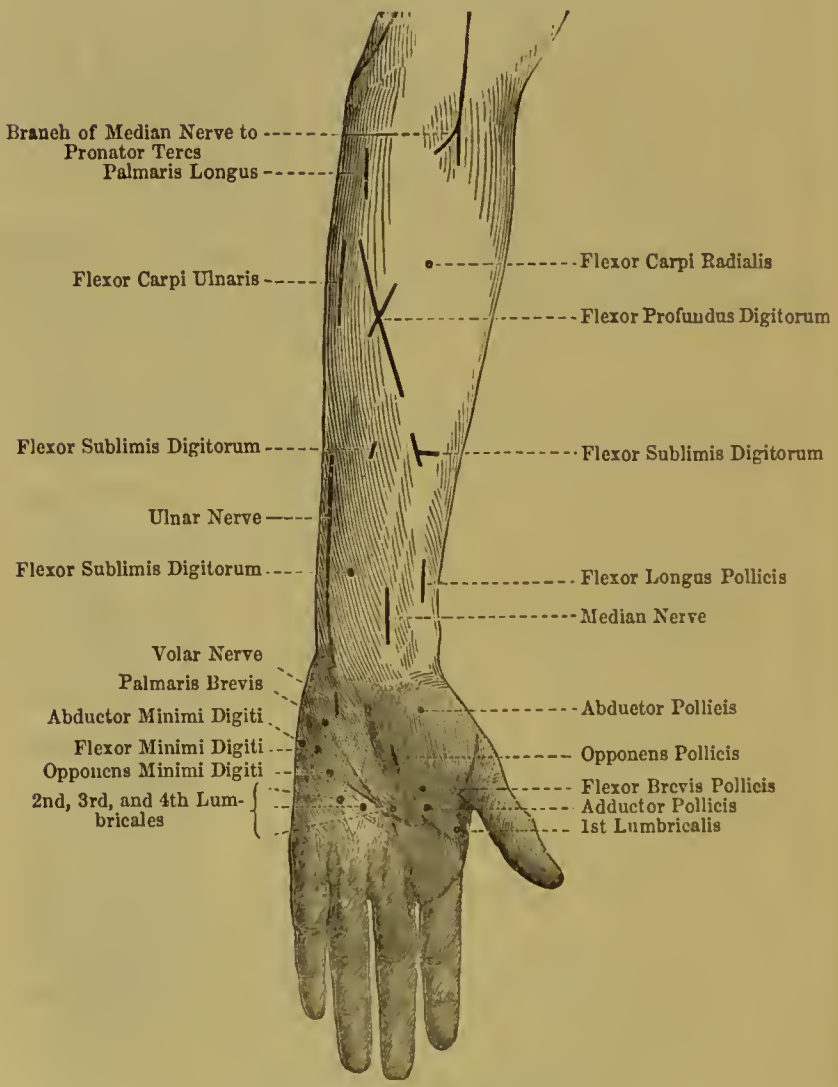
radial side and flexion of the fingers with opposition to the thumb. In the forearm, an inch above the wrist, the nerve lies for some distance between the tendons of the palmaris longus and the flexor carpi radialis, almost quite superficial. Excitation here (see fig. 49) produces abduction of the thumb, with stronger opposition and slighter flexion of the first phalanges of the index and middle fingers. The Median Nerve.

The ulnar nerve may be excited along its whole course from the axilla to the elbow, although by movement of the skin or of the nerves, an unintentional action of the median is easily produced. It is best to take the interval between the olecranon and the internal condyle, since here the nerve does not slip, but can be pressed firmly against the bone. Its excitation produces pain in the long palmar branch and its twigs to the fingers on the volar and dorsal sides of the hand, with contraction of the flexor carpi ulnaris, flexor digitorum profundus, palmaris brevis, muscles of the little finger, interossei, 4th lumbricales and abductor pollicis. After giving off its posterior branches, the nerve lies wholly superficial for a considerable distance above the wrist on the radial side of the tendon of the flexor carpi ulnaris; and it produces when excited here pain in the volar twigs and in the above-mentioned muscles of the hand. The hand is rendered concave, the thumb adducted, the little finger strongly flexed and opposed, and the remaining fingers moderately The Ulnar Nerve.

The Ulnar Nerve.

flexed at the metacarpo-phalangeal articulations. Fig. 50 shows the motor points of the anterior sur-

Fig. 50.



Anterior Surface of Left Forearm.

face of the left forearm; and the method of exciting the individual muscles of the hand is seen in figs.

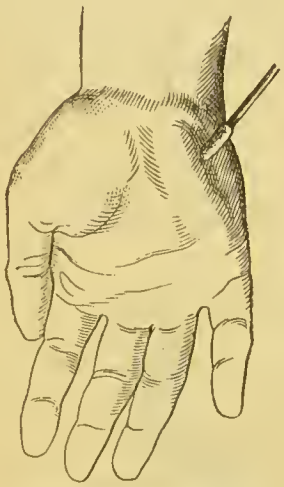
51 and 52, exhibiting the contraction respectively of the opponens pollicis and abductor minimi digiti. The Ulnar Nerve.

Fig. 51.



Opponens Pollicis.

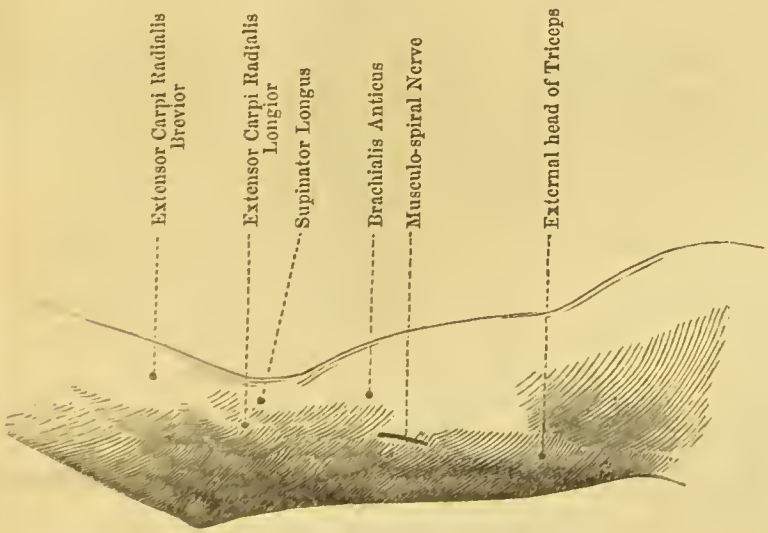
Fig. 52.



Abductor Minimi Digiti.

Fig. 53 shows the motor points of the posterior surface of the left arm. The musculo-spiral nerve

Fig. 53.



Posterior Surface of Left Arm.

The Musculo-spiral Nerve.

is accessible at the posterior edge of the axilla, but it is most superficial and more easily compressed on the outer edge of the humerus, where it passes

Fig. 54.



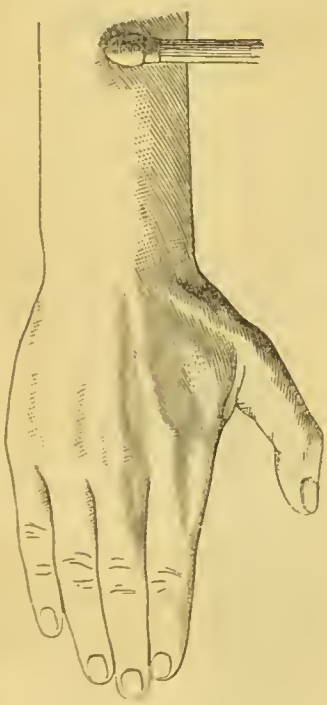
Posterior Surface of the Left Forearm.

round to the front. The spot is readily found by taking the middle points between the insertion of the deltoid and the external condyle, from this

point somewhat outwards. Lower down, between the supinator longus and brachialis internus, it is more deeply placed, but is still accessible. Its excitation above the external condyle causes painful sensations in the region of the superficial radial nerve down to the fingers on the dorsal surface,

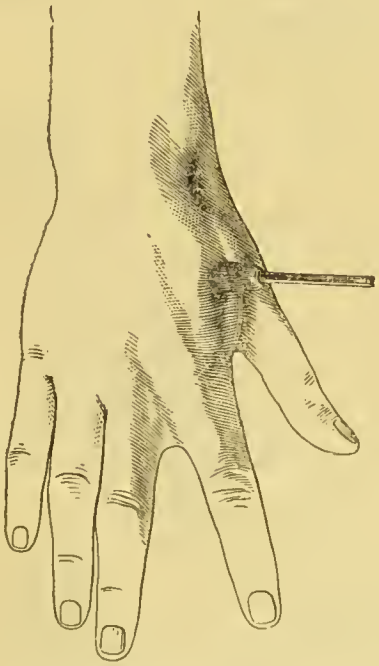
The Musculo-spiral Nerve.

Fig. 55.



Abductor Longus Pollicis.

Fig. 56.



1st Dorsal Interosseous.

with contraction of the supinator brevis, extensor carpi ulnaris, flexor carpi ulnaris, extensor digitorum communis, extensor indicis, extensor minimi digiti, extensor pollicis longus and brevis, and abductor pollicis. It consequently produces supination of the forearm with complete extension of the

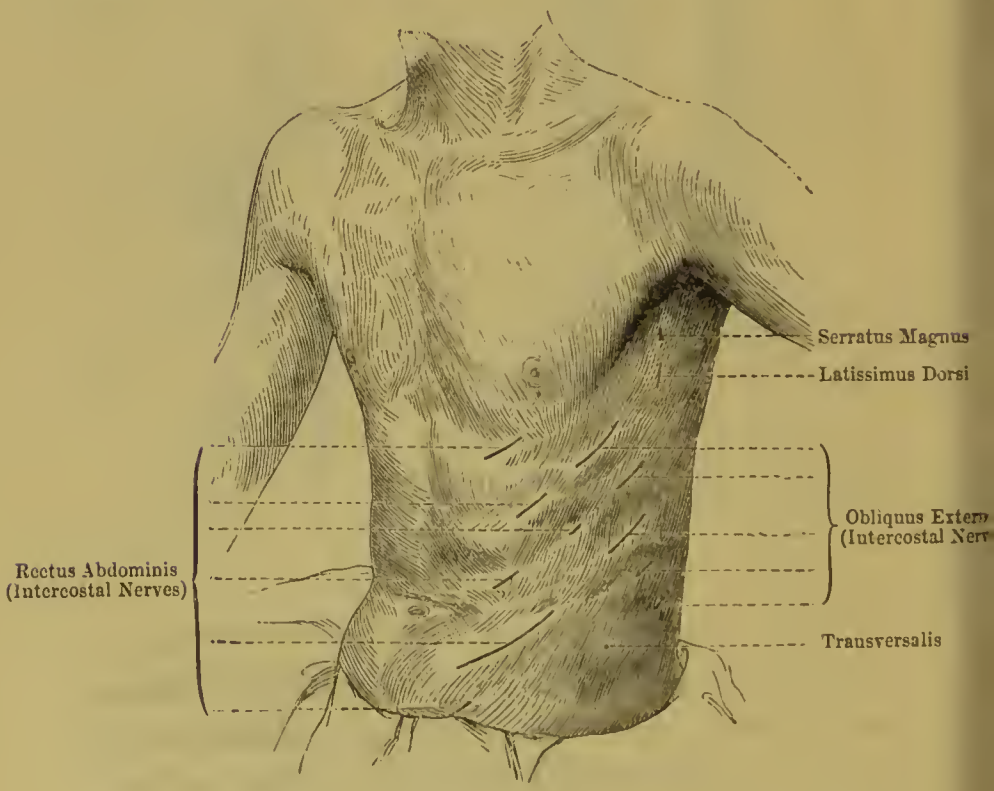
The Musculo-spiral Nerve.

hand and thumb, and extension of the first phalanges of the fingers. The posterior surface of the left forearm is seen in fig. 54, and the isolated contraction of the abductor longus pollicis in fig. 55, and that of the 1st dorsal interosseous in fig. 56.

The Trunk.

Fig. 57 shows the motor points of the surface of the trunk.

Fig. 57.



Surface of Trunk.

Internal Intercostal Nerve.

Excitation of a single internal intercostal muscle may be effected by means of a thin electrode pressed

against the lower margin of a rib, close to the insertion of a digitation of the serratus magnus. During quiet respiration we may thus produce a contraction of the muscle from the place of irritation to the junction of the rib with its cartilage, and thereby a strong lifting of the rib below, and in both ribs it may be plainly seen and felt. Internal Intercostal Nerve.

The abdominal muscles can only be brought into partial contraction by one electrode, since they are supplied by several nerves. The rectus abdominis receives as many nerves as it has fleshy bellies. These nerves enter the muscle at its outer margin, and are only accessible at the point of entrance, being covered in the rest of their course by the obliquus. They are easily discovered at the outer margin, and the excitation of each nerve produces contraction of the corresponding belly of the muscle. The upper portions draw the abdominal wall upwards, and those below the umbilicus draw it downwards. The nerves of the external oblique muscle are to be sought in the lower intercostal spaces, at the origins of the upper digitations of the muscle. Press the electrodes deeply at the free ends of the eleventh and twelfth ribs. There will follow considerable flattening of the abdomen in the region of the contracting portion. Nerves to Abdominal Muscles. External Oblique.

The transversalis is powerfully influenced by pressing an electrode on the soft parts on both sides above the crista ilii, near the outer margin of Transversalis.

Transversalis.

the quadratus lumborum, but even in thin persons this is not always easy. With a strong current, if success is obtained, the action is as powerful as in the strongest voluntary efforts to empty the rectum or bladder.

Splenius Capitis.

Of the muscles of the back the splenius capitis may be excited at its outer margin. A powerful rotation of the head towards the same side is produced. The other deeper muscles of the neck are beyond reach.

Latissimus Dorsi.

The latissimus dorsi, together with the teres major and teres minor, and serratus posticus inferior are generally only accessible to intramuscular excitation.

The Inferior Extremity.

Fig. 58 shows the motor points of the anterior surface of the left thigh.

The Crural Nerve.

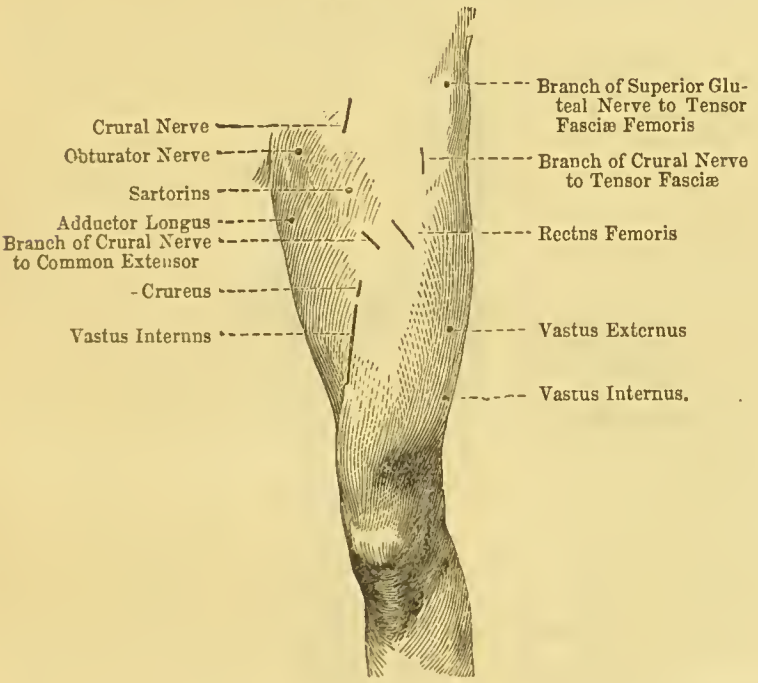
The crural nerve, after its passage under Poupart's ligament, lies wholly superficial in the groove of the iliac muscle, and is accessible for some distance. Its excitation produces very energetic extension of the leg, with severe pain in the course of the greater and lesser saphena nerves, and of the anterior and middle cutaneous femoral, that is, on the front and inner side of the thigh, the knee and inner side of the leg as far as the great toe. Its motor branches can be isolated only in thin persons, but direct excitation of the muscles near the

points of entrance of their nerves always produces a powerful effect.

The Obturator Nerve.

The obturator nerve, or at least the mesh of its twigs, since it divides in the obturator foramen, may be reached from the foramen. Place the electrode perpendicularly upon the horizontal ramus of

FIG. 58.



Anterior Surface of Left Thigh.

the pubes and strongly compress the skin, fat, and pectineus muscle against the bone. This produces very powerful abduction of the thigh, but it is highly painful, partly because the skin is richly supplied with sensitive filaments from the genito-crural nerve, and partly because the obturator itself con-

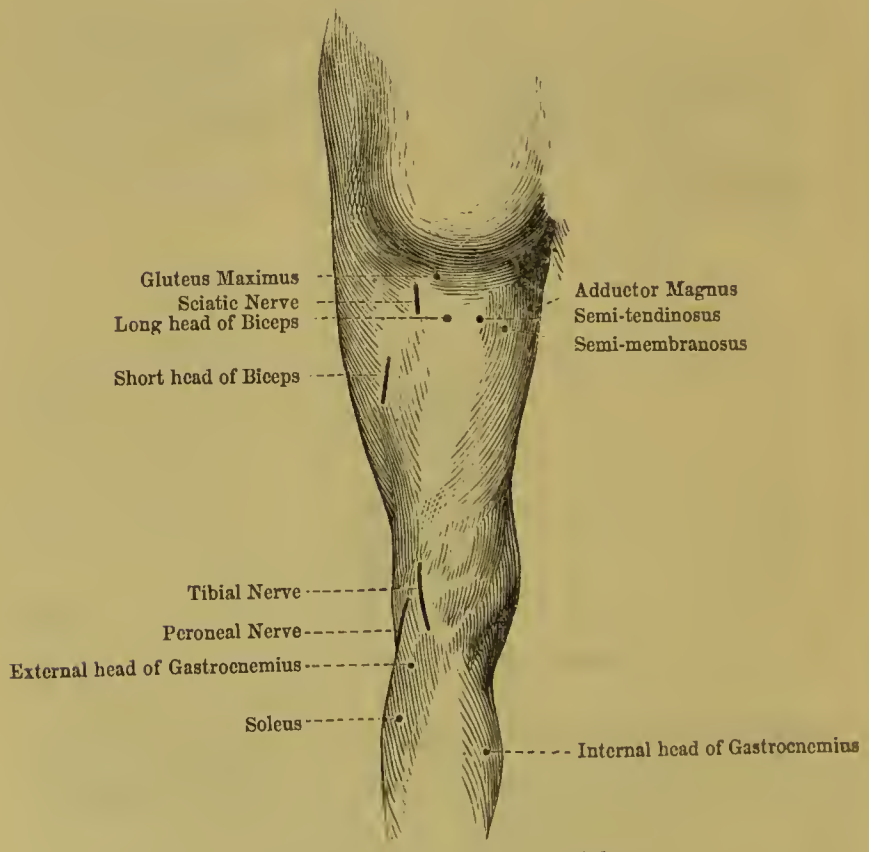
sists largely of sensitive fibres destined to supply the knee and the inner surface of the thigh.

The Superior Gluteal Nerve.

The superior gluteal nerve is withdrawn by its deep position from direct excitation, as is also the inferior gluteal.

Fig. 59 shows the motor points of the posterior surface of the left thigh.

Fig. 59.



Posterior Surface of Left Thigh.

The Sciatic Nerve.

The sciatic nerve, although covered by the thick flexor muscles of the leg, may yet be reached at the

lower margin of the gluteus maximus in the middle point between the great trochanter and the tuber ischii, by using firm pressure with a strong electrode, covered by a rather large cushion of sponge or leather. There results a powerful flexion of the leg and contraction of all the muscles of the leg and foot, with acute pain in all the parts receiving sensitive fibres from the nerve. The Sciatic Nerve.

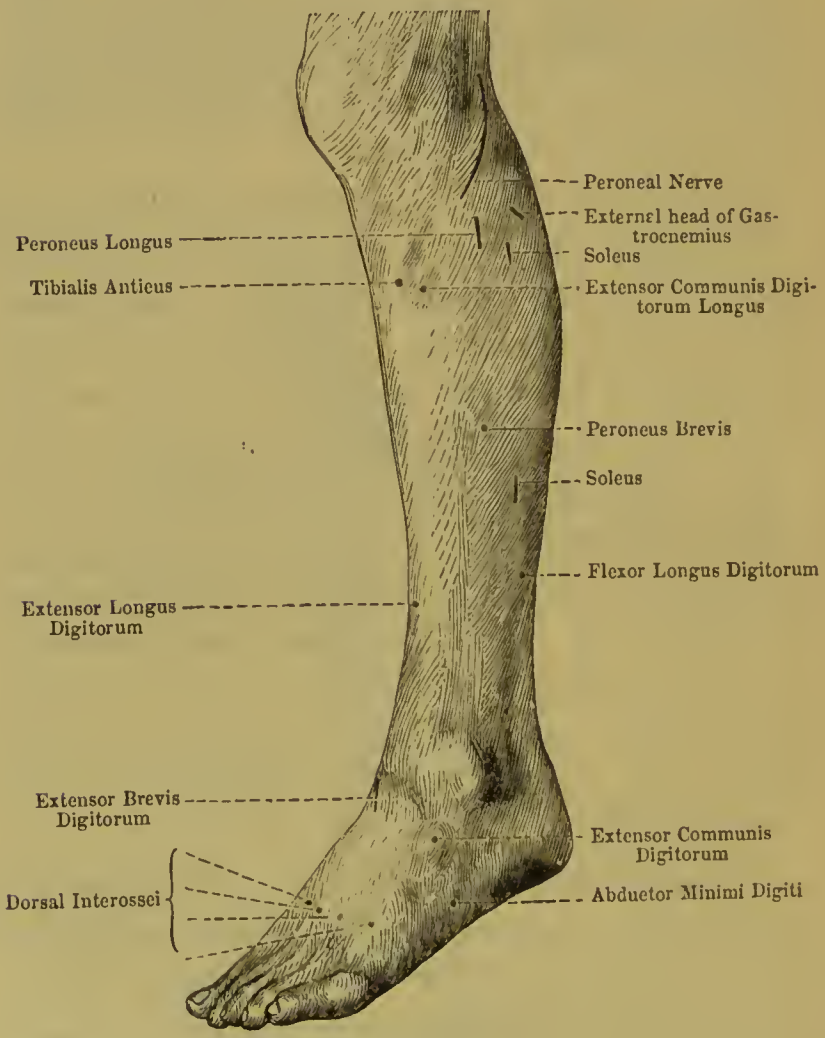
The peroneal nerve may be reached directly it is given off from the sciatic, on the inner margin of the biceps femoris and of its tendon. The excitation is much more certain and precise at the back of the prominence of the head of the fibula, which affords firm resistance to the pressure of the electrode. In this position also the external and middle sural cutaneous nerves, being given off by the peroneal, above the head of the fibula, escape the action of the current. There results contraction of the peronei, tibialis anticus, extensor digitorum longus and brevis, and extensor pollicis longus, with sensation in the cutaneous nerves of back of the foot. The Peroneal Nerve.

The tibial nerve, after the division of the peroneal lies in the ham covered only by the popliteal fascia, the skin and a thin layer of fat. From the power of compressing it against a resisting surface it may be excited with as much certainty as the peroneal. There results an energetic contraction of all the muscles of the back of the leg and the sole of the The Tibial Nerve.

The Tibial Nerve.

foot with painful sensations in the sural nerve and in the sensitive branches of the external and internal plantar. The best position for exciting the peroneal

FIG. 60.



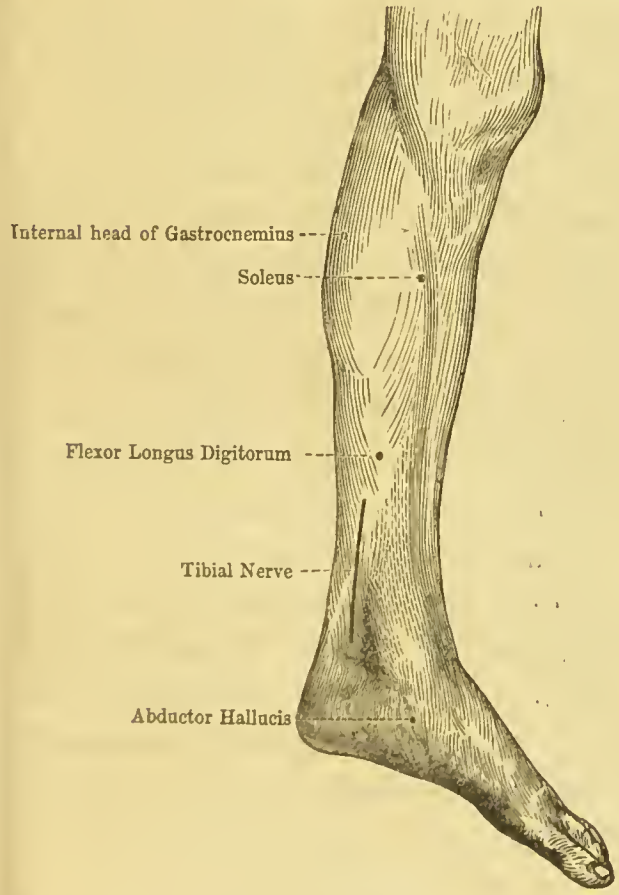
Outer Surface of Left Leg.

nerve is well marked in fig. 60, which shows the motor points of the outer surface of the left leg. Those

of the inner surface are represented in fig. 61, where the tibial nerve after emerging from behind the belly of the soleus may be found in the middle line between the inner margin of the tibia and the

The Tibial Nerve.

Fig. 61.



Inner Surface of Left Leg.

tendo-Achillis, and may be followed downwards as far as the posterior border of the internal malleolus. Contraction of all the muscles of the sole of the

The Tibial Nerve.

foot results from its excitation, and painful sensations in the plantar digital nerves.* .

Electrization of the Central Organs of the Nervous System.

The Central Organs of the Nervous System.

The central organs of the nervous system, as well as the nerve trunks that pass through the great cavities, on account of being completely surrounded by soft parts and bones which cannot be forced into contact with them by external compression, are withdrawn from the influence of the faradic current, unless it be used of excessive strength. On the other hand, an indirect excitation of the brain through the nerves of special sense, especially the optic and auditory, may be accomplished by voltaic currents of medium strength. Excitation of these nerves with strong currents may, in addition to intense sensations of light and abnormal sensations of sound, be followed by vertigo, or even loss of consciousness; and in exciting them the utmost circumspection is necessary, since the amount of reaction displayed by different people varies widely.

* For full details regarding the isolation of single muscles and their physiological action consult Ziemssen, *Die Electricität in der Medizin.* Berlin, 1866; and Duchenne, *Physiologie des Mouvements.* Paris, 1857.

Cutaneous Faradization.

When it is desired to act only upon the skin faradization has many advantages over the other forms of electricity, and in practice it is invariably preferred. There are three methods of applying it. Cutaneous Faradization.

1. *The Electric Hand.*—A moist rheophore (a sponge contained in a cylinder), as shown in fig. 37 (p. 67), is applied to some little sensitive part of the patient's body, the other rheophore is held by the operator, who passes the back of his disengaged hand over the points which he wishes to excite. Electric Hand.

Fig. 62.



Metallic Threads.

2. *Solid Metallic Rheophores.*—The rheophores, figs. 35, 36, 38, and 39, without sponges or leathers, and being quite dry, are applied by their metallic surfaces to the skin, and either kept stationary or moved over it with greater or less rapidity, in proportion to the degree of irritation it is required to produce. If the conical rheophore is maintained for some time immovable, it is termed the *electric nail*, from its action somewhat resembling in sensation a hot nail penetrating the skin.

3. *Metallic Threads.*—A wire brush (fig. 62). This may be moved over the Metallic Threads.

Metallic Threads.

skin (*electric cauterization*), held in contact with it (*electric moxa*), or used to strike it lightly (*electric fustigation.*) In cutaneous electrization the skin must be carefully dried, and in addition sprinkled with some absorbent powder, such as starch or violet powder.

Electrization of Internal Organs.

Electrization of Rectum.

1. *Electrization of the Rectum and Muscles of the Anus.*—An olive-shaped conductor, insulated by gum elastic, is introduced into the rectum and connected with one of the terminals of the battery. A moist rheophore connected with the second terminal is moved over the circumference of the anus, while the conductor is brought into contact with the levator and sphincter ani. To excite the muscular coat of the rectum, the conductor must

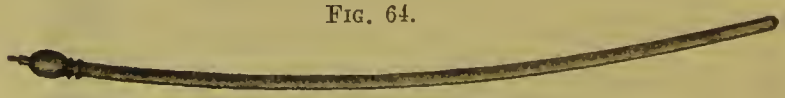
Fig. 63.



Rectal Rheophore.

be moved over all of its internal surface. The rectum must always be first freed from fæcal matter.

Fig. 64.



Urethral Rheophore.

Electrization of Bladder.

2. *Electrization of the Bladder.*—The bladder must first be emptied. To electrize the muscular

Electrization of Bladder.

fibres of its neck, the rectal rheophore must be introduced into the rectum as above described. A curved metallic sound (fig. 64), insulated by being covered with an elastic catheter to within an inch of its vesical extremity, is introduced into the bladder, and drawn back in such a manner that its extremity is brought in contact successively with all points of the neck of the bladder. To avoid the necessity of using the rectal rheophore, Duchenne has contrived what he terms a double vesical rheophore. This instrument is formed of two flexible metallic stems, enclosed in an elastic catheter with a double channel separating them from each other. The two stems have the terminations shown in fig. 66, that when approximated, as in fig. 65, they resemble an ordinary sound. The instrument is closed by pushing the elastic catheter forwards, and is thus introduced into the bladder. The stems being then pushed forward, the ends separate.

Fig. 65.



Double Vesical Rheophore, closed.

Fig. 66.



The same, open.

Electrization of Uterus.

3. *Electrization of the Uterus.*—The uterine rheophore differs from the double vesical only in the curvature of the stems, and in the larger size of the terminal plates. It is introduced closed, as in fig. 67, into the vagina, and then the two plates are made to separate, as in fig. 68. The operator guides each of the plates by the index finger of his free hand, and places them on the sides of the cervix; or the rectal rheophore connected with one pole of the battery may be applied to the cervix, and *two* moistened sponges inserted in cylinders, and in connection with the other pole, may be applied, one to the abdominal parietes above the fundus uteri, and the other to the lower lumbar spine.

Fig. 68.



Fig. 67.

Fig. 67. Uterine Rheophore, closed.
Fig. 68. The same, open.

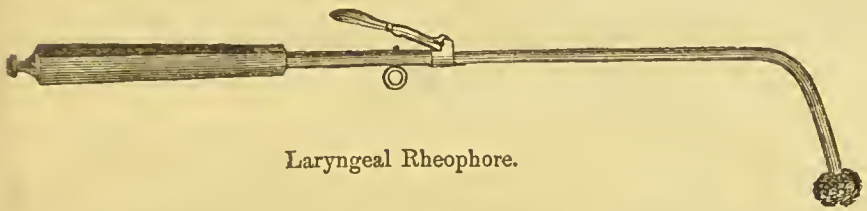
Electrization of Larynx.

4. *Electrization of the Larynx.*—This may be direct or indirect. The more usual method is to apply a moist rheophore to the nape of the neck, and a second rheophore, or a wire brush, as the case may be, to the exterior of the larynx, and in the majority of cases this will fulfil every therapeutic indication. In direct electrization the intervention of the laryngoscope is necessary. In

this procedure, a curved metallic stem, terminating in a small bit of sponge, and protected by a gum-elastic tube, is introduced by the aid of the laryngoscope. This laryngeal rheophore (fig. 69) is provided with a spring and stop, by which the

Electrization of Larynx.

Fig. 69.



Laryngeal Rheophore.

operator is enabled to withhold the current until he sees by the laryngeal mirror that the sponge is in the desired position. A second moist rheophore is applied externally. The muscles of the pharynx may be electrized with a similar director, but this is a proceeding requiring great care, on account of the contiguity of the glosso-pharyngeal, pneumogastric, and recurrent nerves.

5. *Electrization of the Male Genital Organs.*— Moist rheophores are placed upon the scrotum over the testicle or the epididymis. If it be desired to excite the vesiculæ seminales, the bowel is first emptied, the rectal rheophore is then introduced and so directed that its olive-shaped termination may be brought into relation with the vesiculæ. For this purpose it is sufficient to move the rheophore from right to left and *vice versâ*. A powerful

Electrization of Male Genitals.

Electrization of Male Genitals.

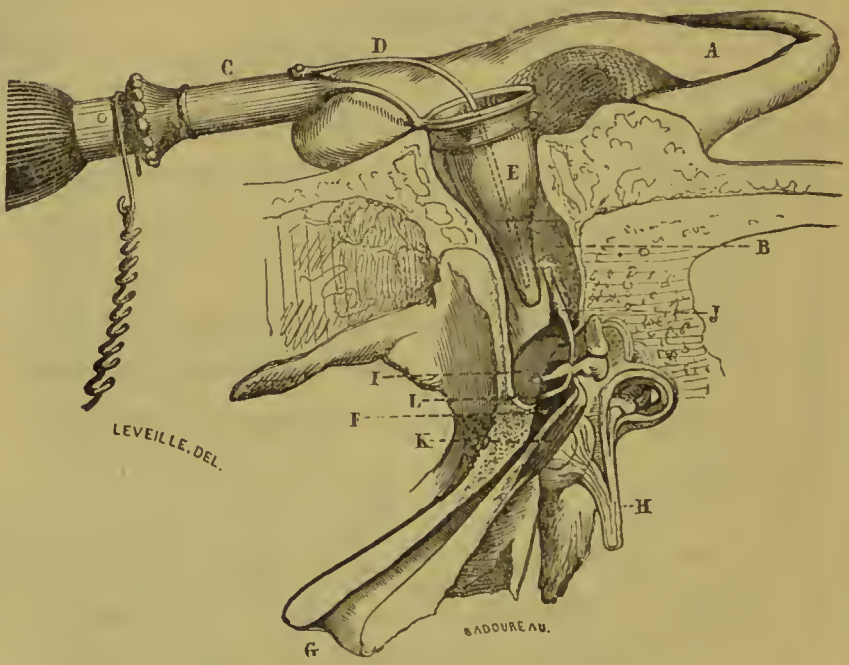
current will penetrate the intestine and reach the vesiculæ, exciting them energetically. The circuit is completed by a second rheophore placed on an unsensitive part of the body.

Electrization of the Organs of the Senses.

Electrization of the Organs of the Senses.

Electric excitation of the senses of sight, hearing, smell, and taste should be performed with extreme

Fig. 70.*



Rheophore introduced into Auditory Meatus.

care, from its liability to react acutely upon the brain. It should never be had recourse to in cases

* A. The concha. B. Meatus auditorius externus, in which the rheophore, insulated by a tube of ivory, E, is inserted. The meatus

in which central excitement must be avoided; and in all cases the minimum dose should be commenced with. *These cautions are especially important with the voltaic current.* Electrization of the Organs of the Senses.

Electrization of the Retina.—Voltaism has the distinctive property of reacting acutely upon the retina, producing sensations of flashes of light when the conductors are applied to any part of the face. A moistened rheophore is applied to the closed eye, and a second to any part of the face. Electrization of the Retina.

Electrization of the Auditory Nerve.—The external auditory meatus is partly filled with tepid water, and a metallic rheophore, insulated by ivory or vulcanite, is placed in it, dipping into the water, the circuit being completed by a moist rheophore on the neck. The operation is shown in fig. 70. Electrization of the Auditory Nerve.

Electrization of the Olfactory Nerves.—A moist rheophore is placed over the back of the neck, and a metallic sound, insulated except at its extremity, is moved over all points of the nasal mucous membrane. Electrization of the Olfactory Nerves.

Electrization of the Nerves of Taste.—A rheophore is placed over the back of the neck, and a second is moved over the base and borders of the tongue. Electrization of the Nerves of Taste.

partly filled with tepid water. F. The tympanum. G. Eustachian tube. H. Labyrinth and auditory nerve. I. Membrana tympani attached to the malleus. J. Laxator tympani externus. K. Tensor tympani. L. Laxator tympani.

CHAPTER III.

ELECTRICITY AS AN AID TO DIAGNOSIS.

Electro-Diagnosis.

ELECTRICITY will assist us in diagnosis only in those conditions in which there is altered muscular contractility, or cutaneous or muscular sensibility, or both. In the normal and healthy state of their tissue muscles and nerves respond to the electric stimulus whatever variety of electricity is employed, but in disease this reaction may be increased or diminished or altogether absent. The irritability of a muscle is tested by ascertaining the lowest power which will cause its contraction. The procedure is as follows:—Assume the case for example to be one of ordinary hemiplegia, say of the left side.

Test of Farado-Contractility.

Take in one hand the two rheophores of a Faradic instrument in action and apply them to one of the muscles—the extensor communis digitorum will do—of the right or healthy side; having found the *lowest power* to which the muscle responds, apply the rheophores to the same points of the corresponding muscle on the diseased side, and note whether there is contraction; if there is, decrease the power of the current, and if contraction still occurs there is increased irritability, or *vice versâ*, as the case may

be. In testing with the voltaic current keep one electrode stationary and interrupt the current by gliding the second over the muscle or repeatedly lifting and reapplying it. It is essential that on both sides there should be exact similarity in the application, and that the electrodes should be placed on identical points of the muscle; and this is especially important with the voltaic current, for healthy muscles answer to it more readily when it flows down the limb than when it flows up, and consequently a reversal of the poles will influence the result.* In testing a case of paraplegia where there is equal disease on both sides, we must be guided by a knowledge of the strength of current usually required to bring about contraction. As a general rule, unless a current that causes energetic and painful action in the muscles of the ball of the thumb produces some contraction, the irritability is impaired. *In either diaynostic or therapeutic electrization the operator should never use electricity upon a patient without first testing it upon his own hand, and if about to apply it to the face, upon his own face.* This is a most important rule, never to be neglected. There is no certain means of securing

Precautions in Mode of Application.

Rule for Strength of Current.

* The current that passes from a nerve centre to the periphery, that is, from the positive electrode placed nearer to the centre, to the negative placed farther from it, is called a "*direct*" or descending current. The reverse current is the "*indirect*" or ascending. Healthy nerve and muscle respond to a lower power when the current is descending than when it is ascending.

Irritability normal.

that the strength of either a voltaic or faradaic current shall not have varied from day to day, and unless we get into the habit of trusting to our own muscles for fine degrees of graduation we shall often be foiled in our object. In a case of hemiplegia it will be found probably that the irritability to both varieties of electricity is normal. This proves the integrity of the muscular tissue. If the muscle also responds to indirect excitation by its motor nerves, we know in addition that the conducting power of the nerves is uninjured, and that the spinal cord has preserved its integrity at the spot where the nerves are given off. The disease is in the brain. But we may find the irritability somewhat diminished. This in hemiplegia will probably be from disuse and a few faradizations will restore it; if not, there is disease of cord or nerve or muscular tissue, and the disease, as a rule, will be in direct proportion to the amount of diminished irritability. But on the contrary, the irritability may be increased when there is often some rigidity. This points to increased vascularity, irritative lesion of brain or cord, or both.

Irritability diminished.

Irritability increased.

Reaction to Voltaism.

Test now with the interrupted voltaic current. Its action on muscle will generally correspond with that of faradism, but in some cases in which response to faradism is diminished or abolished, the reaction to a slowly interrupted voltaic current is not only preserved but greatly increased. On the diseased

side the muscles will respond much more readily to the voltaic current than on the healthy side. When this reaction exists, that to faradism being lost, the nerves do not react to either voltaism or faradism, and the increased irritability is due to the Hallerian irritability inherent in muscular tissue; but why this should be increased over that existing in healthy muscle has not yet been conclusively shown. Ziemssen reports a case of purely traumatic facial paralysis produced by a surgical operation in which the trunk of the facial nerve was completely divided. At the end of three weeks the excitability of the motor nerves to faradism and voltaism was lost. The paralysed muscles, on the contrary, had preserved their irritability to the interrupted voltaic current and responded by a slow contraction, due to the muscular tissue, *without the agency of nerve.*

Voltaic-Contractility increased.

This *muscular* reaction to the slowly interrupted voltaic current is often of great use in the diagnosis of peripheral from central paralysis (*e.g.*, in the diagnosis of paralysis of the facial nerve from facial hemiplegia). Reaction of this kind exists only in peripheral, never in central lesion. In peripheral paralysis there is, in addition, loss of farado-contractility. Observing this in a case of paralysis of the muscles of the shoulder, Duchenne diagnosed local nerve-lesion, and a syphilitic exostosis was afterwards found compressing the nerves. By this same differential reaction it may be de-

Diagnosis of Peripheral from Central Disease.

Diagnosis of Lead Palsy from Paralysis of Radial Nerve.

termined whether, in a case of paralysis of the extensors of the wrist and fingers, the paralysis is due to the impregnation of the system by the poisonous influence of lead or mercury, or to rheumatic paralysis of the radial nerve (a most important question as affecting the treatment). In lead palsy the reaction to faradism is greatly diminished or abolished, and that to interrupted voltaism increased. In rheumatic palsy the reaction remains normal, or is increased to both currents.

These very interesting variations in the electrical condition of nerve and muscle bear an exact relation to the degree in which the nerve maintains its connection with its centre of origin, and no relation to the degree of paralysis of the muscles to the will; for there may be perfect muscular paralysis, as in hemiplegia, the nerve itself being in health, and also the part of the centre from which it sets out, and its electrical condition and that of its muscle unchanged. If, on the contrary, a nerve is separated from its centre of origin by being cut or compressed, which practically severs it, or if this centre of origin is diseased, the digital length of the divided nerve degenerates, the muscles supplied by it waste, and changes of electrical reaction at once become manifest. We have also just seen that the contraction of a muscle in response to electricity depends upon two factors—the irritability of the

intra-muscular nerve fibres and the irritability of the muscular tissue itself, and the *degree* in which either of these is modified, taken in conjunction with the *kind* of modification, will often aid us greatly in prognosis; for muscles equally paralysed may have suffered very unequally in their nutrition, there being absolute electrical changes in some of these, and none in others. We may often positively predict that these latter will rapidly recover. Diagnosis of Lead Palsy from Paralysis of Radial Nerve.

In paralysis from disease of the brain, Duchenne declares that farado-contractility is always unaltered; but Althaus, as the result of the examination of upwards of one hundred cases, states that he found the excitability in some diminished and the muscles flaccid, in others increased (these being cases of early rigidity and irritative lesion), and in others normal. Cerebral Paralysis.

There is no doubt that in the great majority of cases the reaction to all forms of electricity remains unaltered.

In paralysis from disease of the cord there is almost invariably diminution of reaction in the affected muscles to all varieties of electricity; and this reaction will sometimes aid us in the diagnosis—not always easy—between commencing paraplegia and locomotor ataxy. In ataxy—at least in its early stage, electro-muscular contractility is normal—certainly not diminished. Spinal Paralysis.

In hysterical paralysis, electro-contractility is, as a rule, normal, and always so in recent cases, but Hysterical Paralysis.

electro-sensibility (the sensation of muscular contraction) is frequently absent or much lowered.

Wasting Palsy.

In progressive muscular atrophy (Cruveilhier's atrophy) the farado-contractility is normal in the remaining muscular tissue. Its abolition in this disease proves complete degeneration of the muscle.

Essential Infantile Paralysis.

In the so-called "essential" infantile paralysis, farado-contractility is abolished and voltao-contractility increased. Other forms of paralysis affecting children correspond as regards their electrical reaction to the same disease in the adult.

Diagnosis between Real and Feigned Disease.

The condition of muscular irritability, as tested by electricity, will in some cases largely aid us to distinguish between real and pretended disease. I was enabled to solve this question at once in a case in which simulation was believed to exist, and where I was requested by a railway company, in consultation with Drs. Ramskill and Maclure, to make an electrical examination. In the case in question the muscles of the left leg responded freely to faradism, while the same muscles of the right leg exhibited not a trace of reaction to the full strength of a Stöhrer's induction instrument.

Electricity as Proof Positive of Death.

Immediately after death the irritability to all forms of electricity begins to diminish unequally, but it is not completely abolished in all the muscles

until a variable time, never exceeding two hours. If after that interval it has completely disappeared, death is certain; but if, on the contrary, there is no diminution in about half an hour after apparent death, life still probably exists. Electricity as Proof Positive of Death.

Considered solely as an aid to diagnosis, we can get little more assistance from electricity than I have noted above.*

* In considering muscular and nerve response to electricity, it may be well to recall to mind that central and peripheral paralysis may exist simultaneously, as when a tumour causing central paralysis compresses certain nerves directly after their origin and before their exit from the skull. In such a case the muscles supplied by the nerves compressed would exhibit the reaction of peripheral paralysis, but the paralysis would hardly be limited to these muscles, and the others affected would display central reaction. It is necessary also to remember that any non-conducting substance between the rheophore and the muscle (such as an exudation under the skin) might, by resisting the passage of the current, deceive us, and lead us to believe the muscular irritability lowered when it was really normal.

CHAPTER IV.

ELECTRICITY IN MEDICINE.

Limitation of Electricity as a remedy.

THERE is too much belief and too much unbelief in the therapeutic power of electricity. The men who estimate it fairly are quite the minority. It is generally either much undervalued, or else believed to be a sort of modern elixir vitæ, capable of curing a hopeless hemiplegia from destruction of brain tissue, or a paralysis agitans from senile degeneration. Although electricity will do neither of these impossibilities, yet, considered as a remedy, it is of great value in a wide margin of diseases. It will either stimulate or soothe both nerve and muscle, according to its variety and mode of application; it will frequently restore voluntary movement, it will relieve pain, heighten temperature, recall sensation, coagulate the blood, and dissolve or slowly cause the absorption of tumours.

Effects upon Nutrition.

Besides the local and immediate action, electricity exerts also general effects, especially upon nutrition. Sir James Paget, in his Surgical Pathology, quotes an experiment in which the nerves of a frog's hind legs were divided, and while one limb was left inactive the muscles of the other were called into frequent action by faradizing them indirectly through the

nerve trunk below the section. The result was that at the end of two months the faradized muscles retained their weight and texture, and their capacity of contraction, while the unfaradized were degenerated in texture, and had also lost some of their power of contracting. Legros and Onimus electrized with the voltaic current some puppies for a quarter of an hour every day, by placing one of the fore-paws and one of the hind ones in tepid water connected with electrodes. At the end of six weeks those that had been electrized weighed more and had grown larger than those of the same litter that had not been electrized. Heidenheim found that the prolonged action of a continuous current upon an exhausted muscle restored its excitability; that is to say, the depressed excitability increased, and even in a completely exhausted muscle the lost excitability was again established.

Effects upon Nutrition.

Besides effects upon nutrition, electricity may increase the secretions,—for example, in amenorrhœa it may re-establish the catamenia—and it acts generally upon nerve and muscle as a stimulus, putting both into a condition which has been termed electrotonus.* This modification of the natural state of

Effects upon the Secretions.

* Much has been written upon electrotonus and its importance in electro-therapeutics. Electrotonus is simply a name given to signify the state of a nerve while it is being traversed by an artificial voltaic current. While a current of sufficient power is flowing along the nerve, and under certain circumstances for a limited time even after its discontinuance, the natural irritability of the nerve to stimuli is modified—the irritability is

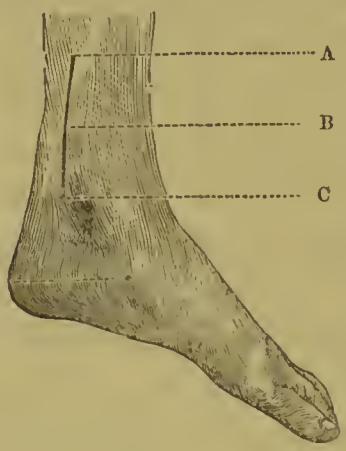
Effects of Artificial Electricity upon the Electricity of the Human Body.

the electricity of the human body does not cause, as a rule, any appreciable effect; but in certain pathological conditions of the nerves it is otherwise. Some persons even are extremely sensitive to electric changes in the atmosphere, and Duchenne cites the

Electrotonus.

increased in the half nearest to the negative pole (catelectrotonus), decreased in the half nearest to the positive pole (anelectrotonus), and unchanged at a point midway between the two poles (point of indifference). Fig. 71 represents a part, A, C, of the tibial nerve which is accessible to direct electrization. If the sole of the foot rests upon a copper plate connected with one of the poles of a faradic instrument in action, and a conical conductor connected with the other pole be applied to the point, A, with the *lowest* power that will cause contraction of the muscles, it will be found that this same power will produce a similar contraction if applied to the point, C. If now a voltaic current from 25 cells of Muirhead's battery be made to traverse the portion of the tibial nerve included between A and C, for five minutes, by holding a well moistened sponge from the positive pole applied just above, A, and a sponge from the negative pole just below, C, and if then while the current is still passing the faradic current is applied as before, it will be found that a lesser degree of power is required to produce the former action of the muscle at C, and a greater degree at A, while at B, midway between the poles, the response remains unaltered.

FIG. 71.



Part of the Tibial Nerve.

There can be no doubt that the production of the general electrotonic state is therapeutically of infinitely greater importance than these lesser variations of anelectrotonus and catelectrotonus, which may probably be explained by differences of tension at the two poles; indeed Dr. Radcliffe declares (see his "Vital Motion," pp. 119-136), that with weak currents the fancied opposition between anelectrotonus and catelectrotonus is entirely illusory.

case of a lady who was invariably during a thunder-storm stricken for some hours with general paralysis. In many of these exceptional instances a feeling of faintness, giddiness, headache, nausea, or even vomiting, may result—a fact which it is necessary to bear in mind. Exceptional Effects.

Before discussing methods of application it will be well to shortly recapitulate the general principles of *all* therapeutic applications of electricity, and to ask ourselves what it is that we propose to do in each case; and, having answered this question, to bear in mind that electricity *per se* is simply a remedy as is opium or quinine, and that it is solely by its administration in measured doses that we do good and not harm. Does the case before us need the stimulant, sedative, or restorative action of electricity? If stimulation, and especially if localized stimulation is demanded, our general rule is to make use either of the faradic or of the interrupted voltaic current, and to localize it in the part diseased. The result of such localization is a larger flow of blood, with consequent increase of temperature and bulk, and general improvement in nutrition. The sedative action of electricity can only be obtained by "charging" the patient with static electricity, or causing the even uninterrupted flow of the voltaic current through the seat of disease—charging it, that is to say, with the "*Constant Current*," which consists not of *any* voltaic General Principles of all Therapeutic applications of Electricity.

The Constant Current.

current from *any* voltaic battery, but of a current from that form of battery which supplies one, *not only continuous, but one which does not vary appreciably in power during the application. And not only so, but of this current so applied to the patient by the operator, that its flow through that part of the patient's body to which it is directed shall be as continuous as the stream of the current from the battery to the conductors. Unless thus applied it is not a constant current, and its therapeutic application will be unsatisfactory.* The effects of the constant current are chiefly sedative, restorative or refreshing, and absorbent or resolvent.

Precautions necessary in applications of Electricity.

Precautions necessary to be observed in all medical applications of Electricity:—

The operator must keep constantly before his attention that he is prescribing or administering an exceedingly powerful remedy, and with all new patients he must act as he would as a matter of course act if he were using a new and powerful drug, namely, *begin with a minimum dose,* and watch its effect. For people differ greatly in their toleration of electricity; and at the risk of tedious reiteration, I would again impress upon the reader that the *dosage* is all important, and that the exact strength of current which suffices to produce the desired effect should alone be used, and not exceeded. If, for example, muscular contraction is sought, use the power which will excite the amount

of contraction required, and no more.* These precautions are especially necessary with the voltaic current when applied to the face, neck, or any part of the head. Duchenne blinded a patient by suddenly applying a current from forty cells to the facial muscles, and he had the candour to publish his misfortune. Sudden applications, and sudden cessations, should especially be guarded against. The cessation shock can of course only occur in cases where the conductors having been held immovable, and the current gradually increased, one or both of them have been abruptly and it may be inadvertently removed; and I have known a patient so frightened by such a cessation shock as to decline further treatment. The negative pole of a voltaic battery, if frequently applied to the same spot, will soon cause a sore, and to avoid this the point of application should be slightly shifted occasionally. To prevent avoidable pain, never "fumble" with the electrodes, but place them at

Precautions in application.

* We all know the tendency of "new brooms," and I have no hesitation in saying that, in the great majority of cases in which electricity has been applied by an unpractised operator, that the application has been both too long and too strong. No man is justified in electrizing a patient without invariably testing the electricity upon himself several times during each application, if only for a second at a time, and always when he either increases or decreases the power of the current. I would particularly impress this rule, for I have known, not one case only, but literally dozens, in which the patient has been submitted, time after time, to unbearable and wholly unnecessary pain, and upon inquiry of the operator it has been found that he had never once applied the electricity to himself.

Precautions in application.

once and firmly in the desired position. Sometimes when a patient is not making progress under electrization, a shorter or less frequent application will entirely change the aspect of the case; for it is possible that stimulation only being needed, this may have been carried to the point of exhaustion.

Electricity has been, and indeed is still, advocated by some writers as of great benefit in a multitude of diseases; but its proper field is principally in disorders of the nervous system, and chiefly in paralysis, in neuralgia and other painful affections, and in some disorders in which tremor or spasm is a prominent symptom.

General Faradization.

Before discussing its localized action, I may refer to a methodical application to the whole surface of the body, which is advocated by Drs. Beard and Rockwell, under the name of General Faradization. They state that they have had large experience in, and they speak very highly of the remarkable effects of, electricity administered in this way in conditions of debility. Their method rests, they say, upon the two principles—namely, "1. That electrization, besides being merely a local stimulant, also exercises an influence over general and local nutrition, at once unique and unrivalled, and that entitles it to the highest rank among constitutional tonics. 2. That the system of making the application exclusively local is both illogical and incon-

sistent; that in the use of electricity, as of every other remedy, constitutional diseases should be treated constitutionally." Their method of procedure is to place the patient with his naked feet upon a sheet of copper connected with one pole, while the other pole is connected by a moistened sponge with the left hand of the operator, who passes his disengaged hand over the muscles of the patient, and sometimes over his whole body. The originators claim for this method a delicacy of graduation to which they attach great importance, not to be equalled by any mere mechanical means; the sensations of the operator produced by the current passing through his body, are his guides to graduation; and they say also that no artificial rheophore can equal the human hand in its adaptability to the different regions of the body. This application is made only with the faradic current; but the same authors advocate a generalized application of the voltaic current under the name of "Centralized Galvanization," their object being to bring the whole central nervous system — the brain, sympathetic and spinal cord, as well as the pneumogastric nerves--under the influence of the galvanic current. One pole (usually the negative) is placed at the epigastrium, while the other is passed over the forehead and top of the head, by the inner border of the sterno-mastoid, from the mastoid fossa to the sternum, at the nape

General Faradization.

Centralized Galvanization.

Centralized Galvanization.

of the neck, and down the entire length of the spine. In General Faradization the chief aim is to affect the *muscular* system; in Central Galvanization, the central *nervous* system. Both are stated to be powerful tonics, adapted for conditions of debility: for great muscular debility, General Faradization; for simple exhaustion of the nerve centres (hysteria, chorea, and so forth), Central Galvanization. The reader will find these methods of electrization fully described in the work of their authors.*

The Electric Bath.

There is another general application which may be of occasional service. This consists of a bath the water of which is in contact with one of the conductors of an induction instrument, or of an apparatus supplying an interrupted voltaic current, while the second conductor is applied to some part of the body that is not immersed, commonly to the upper and back part of the chest. The spinal cord is excited in a general manner by reflex excitation of the peripheral ends of the nerves. This form of application is useful in cases where stimulation of the nervous centres is indicated; and where the application is of such feeble strength as not to provoke muscular contraction, it produces an excitation that will increase muscular power in certain forms of general paralysis. In cases of general debility I

* A Practical Treatise upon the Medical and Surgical uses of Electricity, by Drs. Beard and Rockwell. New York: W. Wood and Co. 1875.

believe that these baths are of decided benefit; but they are only of use when general stimulation is advisable, and in the great majority of cases localized applications of electricity are more beneficial.* The Electric Bath.

* The electric bath has been much advocated of late (chiefly outside the profession), and remarkable statements have been put forth not only of its curative powers in almost every disease, but also of its purely physical and chemical effects. About four years ago I fitted up a bath at a private establishment for the reception of resident patients, and since then I have carefully compared its action with the different methods of localized electrization. Although an elegant and pleasant mode of administering electricity when it is desired to obtain general effects, I have found the bath less beneficial (except in certain gouty and rheumatic cases) than localized applications of electricity according to therapeutic requirements. Either the voltaic or induced current may be used. A bath sufficiently large for the patient to recline in it should be fitted with insulating glass supports and filled with water at a temperature of from 95 to 100 degrees. A large metal plate in connection with one pole of the battery may be inserted at the head, and a second plate in connection with the other pole at the foot. The patient should be protected from direct contact with either plate by a smooth and open wooden framework. With a sufficiently powerful current a portion of the electricity will pass through the body of the patient reclining thus between the poles; but for this method of administration much stronger currents of electricity are required than for ordinary applications, and the bath should preferably be made of some material such as wood, slate, or marble, which is a worse conductor than the human body. This, however, is not necessary when a part of the body not immersed in the bath is connected with one of the poles and the water with the other. Then currents of ordinary strength are amply sufficient. It is convenient in this form of bath for the patient to grasp in his unimmersed hands a copper bar covered with wet flannel and in connection with the second pole of the battery, or a conductor from this second pole may be held almost but not quite in contact with any part of the body immersed in the water. The Electric Bath.

But far more important than the relative merit of the bath as a mere vehicle for electricity is the question whether by its agency metallic poisons can be eliminated from the body. It has been contended since 1855 that if the negative pole of a battery supplying a voltaic current of sufficient power be connected with an insulated copper

Franklinization.

Franklinization, as partaking more of a general application than a local, may be conveniently considered here. This form of electricity has been suffered to fall into unmerited disuse, perhaps from the inconveniences of its application. It has been found in the practice of the National Hospital for the Para-

The Electric Bath.

bath, and if the patient insulated from contact with the copper sides sits in this bath holding in his uuimmersed hands alternately the positive pole, the current entering his body by his arms circulates everywhere from head to foot, and passing out carries with it any contained metallic particles, which it deposits on the surface of the sides of the bath, or dissolves in the water, which must be acidulated with sulphuric acid if lead is to be extracted, and with nitric or hydrochloric acid if mercury. There is no doubt that a current of electricity will promote elimination by stimulating the circulatory and nervous systems, and so will a hot bath, and perhaps the two conjointly will do more than either aloue. I have administered electric baths to patients suffering from plumbism, and have obtained distinct traces of lead in the water of the bath; and I have given hot baths for an equivaleut time but without electricity to other patients, *and have also obtained traces of lead.* Attention has been recently redirected to the subject by the publication by Mr. Sydenham J. Knott, Medical Superintendent of Galvauism to St. Mary's Hospital, of a rapid cure of extensive paralysis from lead, in which not only was lead found in the water of the bath, but the recovery from the paralysis was singularly rapid and complete.* For the details of application which have not been before published, but which were as follows, I am indebted to the courtesy of Mr. Knott. The patient was immersed up to his neck in an ordinary zinc bath filled with water at a temperature of 85°. A pint of sulphuric acid which just acidulated the water was added to the bath. Copper plates, each 6 × 3 inches, were connected with the poles of a Stöhrer's voltaic battery, aud the positive plate was placed at the back of the neck about three inches from the skin, while the negative was similarly placed between the aukles. In about fifteen miuutes the negative plate was removed from the ankles and slowly passed along the limbs, being kept from one to two inches from the skin, and lastly passed over the abdomen. 16 cells were used in the beginning, and the number was

* The *Lancet*, Oct. 14, 1876, page 526.

lysed and Epileptic, and in private cases coming under my own observation, of considerable value. *Facial neuralgia*, for example, which has resisted other modes of treatment, may occasionally be relieved with rapidity and permanently by drawing (a) Facial Neuralgia.

gradually increased to 28, and then decreased by degrees to 14. The subsequent irritation of the skin was very great, sometimes keeping the patient awake for hours. The urine was greatly increased and the bowels acted freely. Mr. Knott has since treated three cases of a milder form, and they all, he informs me, recovered without any medicine. On the other hand. cases of equally rapid recovery under the use of localized electrization have been witnessed in the practice of the National Hospital for the Paralysed and Epileptic. Mr. Knott's case was really a powerful localized application of electricity while the patient was in a bath, and it is an additional proof of electricity being of primary and not of merely secondary importance in the treatment of suitable cases of paralysis; but it does not tend to confirm the statement that electricity will *aid more in the elimination of metallic* than of non-metallic substances, and this qnestion must still be said to remain *sub judice*. The Electric Bath.

Several "Electric Bath" establishments exist in London, and there are few practitioners whose patients do not now and again bring them wonderful tales of marvellous cures from their use, and ask to be allowed to try them. Such patients should be instructed how to take an electric bath in their own bath or bedrooms, under the direction of their own medical adviser, and there is the less reason for letting them run the risk of unscientific and perhaps injurious treatment, now that reliable batteries can be obtained, which act almost automatically, and require so little care to maintain them efficient. Again, to localize electricity technical knowledge is required, but any servant of ordinary capacity can administer an electric bath, if *cautioned explicitly as to the power of current to be employed*, and he or she may safely be allowed to do so in gonty and rhenmatic affections. In such cases both forms of electricity are beneficial, but the preference should generally be given to the voltaic. Chronic, gouty, and rheumatic exudations have in my experience lessened in size, and have sometimes disappeared, after a course of voltaic baths, the current being passed through each of the swollen joints, and its direction frequently changed by the commutator of the poles. The length of such a bath should be from a quarter to half an hour.

sparks along the track of the affected branch or branches of the trifacial nerve. Sometimes also

(*b*) Sciatica.

obstinate sciatica has been partially or altogether removed; so also

(*c*) Facial Spasms.

facial spasm (tic convulsif), as in the following instance. A female, forty-eight years of age, had suffered for thirteen years from spasm of the muscles of the left side of the face. The distortion produced by the spasm was very great, and was apt to be so much exaggerated by slight emotion, even such as would be caused by having to address a stranger, as to make speaking difficult, and to prevent proper attention to her occupation as a small shopkeeper. An experimental trial was made of electrization by sparks along the lines of the nerves distributed to the affected muscles. After the third application the spasm was manifestly relieved, the distortion being diminished, and the paroxysms occurring less frequently. By persisting with this treatment thrice weekly over a period of two months, so great an amount of relief was obtained that little distortion of the face remained, and the patient was able to pursue her business with comfort. Electrization by sparks over the larynx has been found so effective in the

(*d*) Emotional Aphonia.

relief of cases of hysterical or *emotional aphonia*, even those of long standing, that it is well to use it in the treatment of these cases before having recourse to induced electricity. In six or seven recent cases, this form of application repeated twice or thrice

effected a complete cure.* One of these cases was of nine, another of six months' duration. The remainder had lasted from four weeks to three months. The seventh case did not receive any benefit from the use of static electricity, and the other forms of the agent proved equally ineffective. The case recovered slowly under general treatment. Electrization by sparks over the affected spot has often proved of great benefit in removing the *localized excessive sensitiveness* not unfrequently found in hysterical cases, particularly in the spinal region. *Tremor*, whether general or local, is sometimes largely relieved by insulating the patient, and charging him with positive electricity for a period of twenty minutes to half an hour. Other applications failing, I would advise always in cases similar to the above, a fair trial, say half a dozen sittings, of Franklinization.

(*d*) Emotional Aphonia.

Localized Excessive Sensitiveness.

Tremor.

There is a special method of electrization originated by Dr. Radcliffe, and which has very much to recommend it both in theory and practice. The investigations of this distinguished physician in animal electricity led him to the conclusion that the primary condition of this electricity is not current but static.† The state of muscle and nerve during rest is that of charge, during action of discharge. The sarcolemma is proved by many

Dr. Radcliffe's Mode of Electrization.

* If Franklinization fails, the wire brush should be used with the induced current, and well brushed over the anterior surface of the neck.

† Vital Motion as a Mode of Physical Motion, by C. B. Radcliffe, M.D., &c. Macmillan. 1875.

Dr. Radcliffe's Mode of Electrization.

experiments to be sufficiently non-conducting to allow it to act as a dielectric, and so also the neurilemma. Positive electricity having its origin in the molecular reaction of the blood and elsewhere, is developed on the outside of the sarcolemma or neurilemma, and as their sheaths are dielectric the effect of this development is the *induction* of an equivalent charge of negative electricity on their insides. Hence the sheaths of the muscular and nerve fibres become charged precisely as a Leyden jar is charged. Hence, also, the particular view of muscular action which Dr. Radcliffe advocates, namely this, that the elongation of muscular fibre is caused by the elastic sarcolemma being compressed at right angles to its surface by the mutual attraction of the two opposite electrical charges disposed on its two surfaces (an idea which is proved to be practicable by a most ingenious experiment), and that the contraction follows upon discharge in consequence of the sheath being then liberated from the cross compression and left free to yield to its own innate elasticity. The sheaths of nerve fibres are subjected to the same pressure of the two opposite charges, but they do not exhibit the same elongation under charge and contraction because they are less elastic than the muscular fibres. This view explains all the electrical phenomena of muscle and nerve as well as the current theory of Du Bois-Reymond, and it

Dr. Radcliffe's Positive Charge.

leads to important consequences in electro-therapeutics. If the sheaths of the muscles and nerves are thus dielectric it is to be supposed that an artificial charge of positive or negative electricity will affect them like the natural charge. If the outside be supplied with a positive artificial charge, an equivalent negative charge will be induced on the inside, and *vice versâ*. Moreover, if the natural charge was one in which the outside of the sheath was positive, it was to be supposed that the communication of positive electricity to the outside would be favourable to the irritability of the nerve or muscles; and so, indeed, it proved to be by many experiments, and not only so, but also that the opposite charge of negative electricity is less favourable. It was shown in fact that irritability may be long preserved, and renewed more than once by the positive charge, in a way which could not be done by the negative charge. The experiments are too many to be introduced here, but the conclusion from them is applicable not to statical electricity only, but also to voltaic electricity, for Dr. Radcliffe shows good reason to believe that voltaic electricity acts upon irritability not by its current so much as by *the charge associated with this current*, which charge may be made positive or negative by putting an earth wire to one or other of the poles. At all events, when a part of the body is included in the voltaic circuit it may be all

Dr. Radcliffe's Positive Charge.

Dr. Radcliffe's Positive Charge.

charged with positive electricity if an earth wire be put to the negative pole, or with negative if an earth wire be put to the positive pole; and the conditions are favourable to irritability in the former case, unfavourable in the latter. This is the fact insisted upon. It is of no moment whether this charge, with which the animal Leyden jars are to be charged, is from a friction machine, or whether it be from a voltaic battery by running off the opposite electricity by an earth wire. What is wanted is to charge the outsides of the sheaths positively as they are charged naturally. What is aimed at is to put the fibres by this means in the condition most favourable to the preservation or recovery of their irritability—*not to provoke this irritability into existence by shocking it;* and certainly there is much in theory and much in practice to recommend this view as one which opens out quite a new field in electro-therapeutics.*

Differential Use of Voltaism and Faradism.

The question of the differential use of the voltaic current, as well interrupted as constant, and that

* It is hardly necessary to say that more than one view may be taken of the electrical condition of muscle and nerve during the state of rest. There may be the "current" theory of Du Bois-Reymond, or the above stated "Leyden Jar" theory, or what Dr. Radcliffe has recently proposed to call the "electro-motive element" theory, and which he now adopts. According to it each fibre and cell in quiescent muscle and nerve may be looked upon as an electro-motive element in the state of open circuit—a view which leads equally with the "Leyden Jar" theory to the conclusion that the electrical condition of muscle and nerve during rest is *statical*. It is this result only that is therapeutically important, for upon it Dr. Radcliffe bases the system of treatment set forth in the text.

of faradism, has been largely discussed of late years, and for some time divided electro-therapeutists into two great schools, the Faradists, led by Duchenne, in France, and the Voltaists by the late Professor Remak, in Germany. The advocates of the voltaic current claim for it an action *sui generis* upon the nervous centres, an action which faradism can in no way replace. Benedikt, in his "*Electro-Therapie*,"* contends that the voltaic current will *directly* affect the brain and cord. He advises, in cerebral disease, that it should be applied to the long or short axis of the cranium, sittings not to exceed thirty seconds, and to be stopped instantly on the occurrence of the slightest giddiness. The electrodes must be maintained immovable, and may be applied to each mastoid process, to each temple, or to the frontal and occipital protuberances. He advocates still more strongly, for symptoms of intracranial origin, the so-called "galvanization of the sympathetic"—its cervical ganglia. One electrode may be deeply pressed into the auriculo-maxillary fossa, and the other, with a good-sized sponge, applied over the sixth or seventh cervical vertebra, or to the manubrium sterni, close to the border of the sterno-mastoid. The duration of the application should be from one to three or four minutes and with from ten to twenty cells.

Differential Use of Voltaism and Faradism.

Electrization of Brain.

"Electrization of Sympathetic" (so called).

* Electro-Therapie, von Dr. M. Benedikt. Vienna, 1868.

Electrization of Cord.

Whether voltaization can be localized in the sympathetic or not, very powerful effects are produced by the electrodes placed in the above positions, and *when so applied the greatest caution must be exercised by the operator, as also in cerebral galvanization.* Giddiness, syncope, and convulsions are recorded as the sequel of a too powerful or too prolonged application. Benedikt also advocates galvanization of the cord, by keeping one sponge, usually the positive, stationary, and moving the other up and down by the sides of the vertebræ, about forty times at each sitting: or by one pole on the spine and the other on a nerve or muscle. After galvanization of the nervous centre has restored voluntary power he advises that the nutrition of the muscles should be aided by localized faradization. The reader will, in any applications to the head and face, do well to remember the cardinal rule, never to apply electricity to a patient until he has first tested it upon himself.

Relief of Pain.

Electricity has been fully proved to be sometimes unapproached in its power of *relieving pain.* None of its therapeutic results is more firmly established, and were it in no other respect of use, the services of electricity here would entitle it to the foremost rank as a remedy. I refer especially to its application in neuralgia. The constant voltaic current is the form in which it must almost invariably be applied, both electrodes being held firmly pressed and immovable upon the skin. Faradization is seldom of

any use except with the wire brush as a counter-irritant.* Franklinization, if voltaization fails, should always be tried, the patient being insulated and simply charged with static electricity by being connected with the prime conductor, while the machine is kept in rotation for about fifteen minutes. If this fails, sparks may be drawn in the track of the affected nerve or nerves; but the voltaic current in nineteen cases out of twenty, where electricity is advisable, must be our resource. The electrodes should be so applied as to include in their circuit the part or nerve affected. The number of cells should be the highest number that the patient can bear without pain or discomfort, and care should be taken not only to maintain the conductors quite immovable, but to avoid shock by abruptly shutting the electricity off or on. Two cells should be commenced with, and the current so gradually increased that no shock is felt, and at the end of the application it must be as gradually decreased, for it must be remembered that an abrupt removal of the sponges would give a shock. The length of application should be from five minutes to ten minutes, and the frequency once or twice a day; but I have met with the best results in obstinate cases by applying the current as frequently

Relief of Pain.

* Cutaneous faradization carefully localized in the skin and not allowed to reach the muscles, will occasionally be of service in the treatment of those cases of neuralgia in which great cutaneous anæsthesia is present.

Relief of Pain. as the paroxysms of pain recurred. This treatment was directed to be carried out in the case of a patient under the care of Dr. Radcliffe in the National Hospital, who for two years had been subject to attacks of neuralgic pain occurring from six to thirty times daily. She was galvanized twenty-seven times upon the first day. There was rapid improvement: the attacks after a month's treatment were reduced to one or two weekly, and in three months she was discharged cured. Althaus considers that the positive pole should always be applied to the seat of the disease. In my experience I have not found the direction of the current of importance, but only that it should be *constant*.* The seat of the disease in true neuralgia is always in the posterior nerve-root, and one of the electrodes should be placed as nearly over this as possible. I generally place the negative pole with a large sponge on the spine over the point of origin of the nerves affected, and apply the positive pole to the painful spot, and if there be more spots than one, to the different spots in succession. The result of this is almost uniformly good, and it is seldom that considerable relief is not afforded, even if a cure do not result, and this in most varieties of neuralgia, whether centric, reflex, or constitutional. The number of cells must be regulated according to the region affected. In the face it is best to com-

* Dr. Poore correctly and wittily observes, that there is no connection between *anode* (positive pole) and "*anodyne*."

mence with about two, as above recommended, for the sensitiveness of the retina varies so greatly. On the occurrence of the least giddiness the application should be discontinued, and fewer cells or one only used. As a rule it is desirable to use the highest number of cells *that can be borne without discomfort.** This is a most important rule, for batteries differ so much that it is impossible to lay down an absolute rule as to "*number of cells*" to be used in a given case. Professor Eulenberg, who has had wide experience, considers sciatica as by far the most curable of neuralgiæ—many cases requiring only from three to five sittings. Intercostal neuralgia he has never known benefited. In ordinary trigeminal neuralgia he speaks strongly of the constant current as a palliative, but doubtfully of its power to cure. In cervico-brachial neuralgia it divides, he says, the field with hypodermic injection of morphia. Dr. Anstie, while indorsing this, places a considerably higher estimate on its curative power in ordinary trigeminal neuralgia, and he quotes two cases treated by Professor Niemeyer. "The patients," he writes, "were respectively aged sixty-four and seventy-four, and the duration of the neuralgia had been respectively five, and twenty-nine years; in both the pain was of the most

Relief of Pain.

* The degree to which the needle of a galvanometer is deflected by the current is only useful as indicating the relative power at different dates of any one battery, for currents of electricity from different batteries deflecting a galvanometer to an equal degree may differ wholly in their physiological action.

Relief of Pain.

severe type, and in both the success was most striking. In one, every possible variety of medication, and several distinct surgical operations for excision of portions of the affected nerve, had been quite vainly tried. The cases are altogether among the most interesting facts in therapeutics that have ever been recorded." Galvanization of the cerebral hemispheres has been found very beneficial in true migraine (sick headache): the electrodes being applied to each temple or to each mastoid process. Begin with not more than two or three cells, and for not longer than a minute, and stop upon the occurrence of the least giddiness. In angina pectoris one pole may be applied to the spine and the other to the cardiac region. Neuralgia of other parts must be dealt with according to the rules of application already enunciated. The reader will find the subject very exhaustively considered in Dr. Anstie's work.* He quotes some extremely severe cases in which the effect of Electrization was to arrest the pain in a few sittings, and to procure a remission for several days or even weeks; and I have had several cases which I believe to have been as fairly cured as an ague fit may be said to be cured by quinine. Dr. Russell Reynolds also quotes the case of a patient, a lady, who for twenty years had suffered from an extremely severe neuralgia of the ophthalmic branch of the fifth,

Relief of Sick Headache.

* Neuralgia and the Diseases that resemble it. By Francis E. Anstie, M.D., &c. London: Macmillan and Co. 1871.

which recurred daily, and from which her health had greatly suffered. It was not only relieved but removed by a single application. Relief of Pain.

The following cases illustrate the good to be obtained from the voltaic current:—

A lady, fifty-one years of age, consulted me in May, 1876. She informed me that for several years she had suffered much from facial neuralgia, in spite of varied treatment. As a rule, not more than a week elapsed between the attacks, which sometimes came on three or four times daily. Her longest interval for some years had been about four months. She was somewhat weak and anæmic, but her general health seemed fairly good. The pain always came on in the right eyeball, and radiated thence over the brow, temple, and right cheek; and an attack of more than ordinary severity would be followed by impairment of sight, and sometimes by vomiting. I found the right brow, orbit, and cheek very tender upon pressure, but not apparently more so in any one spot than another. During a severe paroxysm of pain I applied the negative pole from five cells of my battery to the back of the neck, and held the positive pole (a moistened sponge in a cylinder) immovable upon the closed eye for about three minutes, and then for a similar period respectively to the temple, brow, and cheek, the entire application taking about a quarter of an hour. The pain was entirely dissipated, and did not return until

Relief of Pain.

the next day, when I instructed her maid how to apply the electricity, directing her to do this as frequently as the attacks of pain came on. Treatment was conducted in this way for six weeks, the greatest number of applications in one day being four. Relief was invariable, though pain did not always disappear. The attacks gradually grew less frequent and less severe, and at the end of the above period had quite ceased. Three months afterwards the patient informed me that there had been no return of pain.

For the notes of the next case, which occurred in the practice of the National Hospital for the Paralysed and Epileptic, I am indebted to Dr. Sturge. The patient suffered from neuralgia of the nerves of the right arm. The present attack came on four months before the patient began to attend the Hospital. The onset was sudden; the pain resembling that of a dreadful toothache. It was shooting and tingling in character and paroxysmal; it would come on for four or five minutes, and then go off for a few minutes. The attack lasted three or four hours at a time, and then she would be free for several hours. It was always better when she was warm in bed, and was liable to be brought on if she touched a cold sheet with her fingers. The whole arm appeared tender.

She had continued to suffer from these attacks up to the time of her attendance at the hospital. At that time there were no tender spots.

Relief of Pain.

She was ordered the continuous current to the arm, the positive pole applied to the back of the neck, and the negative maintained in contact with different parts of the arm. Each sitting lasted from ten minutes to a quarter of an hour, the negative sponge being applied to one spot for about a minute and a half or two minutes, when it was moved to another. The electricity was applied three times a week. At the end of a month she had improved very much, and she ceased to attend.

Paralysis.

But it is in the many disorders that are classed under the heading of paralysis,* that the chief field for the employment of electricity is found, and especially for its localized employment. In all cases the first step is to ascertain the condition of the muscles as regards their irritability to the interrupted voltaic and faradic currents. They must be tested as described at page 106. Having found the degree of reaction, it is as a general rule, to which, however, there are some exceptions, advisable to treat them with that current to which they most readily respond. Where, *after three or four applications*, there is no contraction under either current, electricity will do no good. Where reaction is normal, electricity will

* Cases of functional paralysis from slight pressure are occasionally met with. Such a case was that of a lady who consulted me for a weakness of the extensor muscles of the right foot brought on by wearing a tight boot. Three faradizations completely restored the power of the muscles.

Paralysis.

usually not aid in restoring voluntary power, though it may prevent the muscles from wasting; but where reaction is lessened it will often prove of the greatest service, and in all cases it is likely to preserve the nutrition of the muscles, a point which in protracted paralysis is of the highest importance.* In such cases, if we can do no more, we should endeavour, in the words of Sir Thomas Watson, "to preserve the muscular part of the locomotive apparatus in a state of health and readiness, until peradventure that portion of the brain from which volition proceeds, having recovered its functions, or the road by which its messages travel having been repaired, the influence of the will shall again reach and reanimate the palsied limbs."

Paralysis. Irritability to Voltaism increased.

But there are other instances in which, although the muscles give no response to faradism, their irritability to the interrupted voltaic current is not only preserved but increased. Under the use of this current the increased irritability will usually diminish; ten cells will soon be wanted to produce the amount of contraction that at first was given to five, and then ensues generally a gradual return of response to faradism. Use then faradism only. There is a remarkably interesting record of a case

* In many cases where reaction to faradism is diminished but still extant, the passage of a constant voltaic current through the *nerves* of the paralysed muscles will for the time increase their irritability to faradism.

of paralysis of the deltoid, which illustrates the above points, in the *Lancet* for 1866, vol. ii. p. 576. It occurred in the practice of my predecessor at the National Hospital for the Paralysed and Epileptic, Mr. J. Netten Radcliffe. The patient was a blacksmith, aged 25 years. After several days' suffering from severe "rheumatic pains," so called, in both shoulders, but particularly in the left, he lost suddenly, while working with an ordinary sized hammer, one morning, the power of raising his right arm. When first seen, five weeks after this occurred, the deltoid and infra-spinatus muscles of the right side were found to be completely paralysed, and there was some wasting of the former muscle. The contractility of both muscles to faradism was annihilated, the electric sensibility was diminished over the infra-spinatus, and this form of sensibility, and the sensibility to heat, cold, tickling and touch, were absolutely wanting in a triangular space (the apex pointing downwards) over the deltoid, measuring two inches and a half at the base, and five inches from the base to the apex. Under powerful faradization seven times repeated at intervals of three days, not a trace of contraction could be excited in the paralysed muscles, and the wasting evidently increased. The interrupted voltaic current was then tried. With thirty-five cells of a Becker-Muirhead battery, which produced no effect on the healthy left deltoid and infra-spinatus, a

Paralysis. Irritability to Voltaism increased.

Paralysis. Irritability to Voltaism increased.

marked contraction of both paralysed muscles was excited, with forty-five cells (also ineffective upon the healthy muscles) an energetic contraction. Mr. Radcliffe from this time used the interrupted voltaic current only, thrice weekly, and each time about ten minutes, until it had been applied thirty times. At the end of this period seventy-five cells were required to produce the amount of contraction formerly caused by forty-five, and under the full force of the current from the primary coil of a large Stöhrer's induction apparatus, slight contraction was produced in the deltoid. The further wasting of the muscles appeared also to have ceased, although they did not gain in bulk.

At this time treatment was suspended for two months, the patient being compelled to leave town. In the interval, not only was the little ground which had been gained by electrical treatment lost, but the paralysed muscles had become more and more wasted, and it was now clear that the supra-spinatus also suffered. The wasting indeed was so great that of the deltoid barely a filmy layer of fibres could be perceived to remain. Faradization over the affected muscle did not excite a trace of contraction. But again the interrupted voltaic current caused marked contraction, and pursuing the same course that he had done before, Mr. Radcliffe used daily, for about a dozen times, this form of current only. At the end of the twelve applications, on

using the full force of the current from the primary coil of a large Stöhrer's induction instrument, distinct but slight contraction of the deltoid and infraspinatus occurred. From this period faradization of the paralysed muscles was persisted in four times in the week.

Paralysis. Irritability to Voltaism increased.

The history of this case was not completed in the account given by the *Lancet* reporter. I am now able to give the result. The affected muscles steadily increased in bulk, their electro-contractility improved, sensibility to the electric current, touch, tickling, heat and cold, returned, and at the end of four months the patient was enabled to use his right arm freely and return to his ordinary occupation. At this time no difference in appearance could be distinguished between the right and left deltoid, and voluntary control was as complete over the one muscle as the other; but the electro-motility of the right muscle was not equal to that of the left. In the autumn of 1869 this case came under my observation. During the interval the man had followed his occupation, using with freedom even the large hammer. But about four weeks before placing himself under medical care again he had begun to suffer from severe erratic pains in the right arm and forearm, and an inability to wield the hammer freely. In bulk of muscles and voluntary action no difference could be detected between the right and left arms. The right deltoid was

Paralysis. Irritability to Voltaism increased.

apparently as fully developed as the left. There was no alteration of sensibility of any form over the right arm, and all the muscles responded to an induced current of ordinary strength, an interrupted voltaic current producing no contraction until its force was raised to a point that it would act upon healthy muscles. But the motor effect produced on the right deltoid by induced currents of equal strength was much less than on the left.

I had under my care recently a gentleman who had resided for some years upon the west coast of Africa. The muscular symptoms were those of lead palsy; the extensors of the fingers and the muscles of the thenar eminence had almost entirely disappeared in both arms, there being complete flattening of the ball of the thumbs. There was no lead line and no history of lead, but there was enlargement of the liver, and there had been more than one attack of jaundice. The voluntary movements of the affected muscles were almost entirely abolished. The wasting and loss of power began, after an attack of remittent fever, about two years before, and in nine months had reached the state in which the patient was first seen, when he returned to this country for treatment. Iodide of potassium, sulphur and alkaline baths, and other remedies administered for several months, had caused no improvement. On testing the affected muscles there was not a trace of reaction to the full strength of

Stöhrer's induction instrument, but distinct contraction to the interrupted voltaic current from ten cells of the Becker-Muirhead battery. The reaction in the other muscles of the arm was normal to both currents. The interrupted voltaic current from twenty of Muirhead's cells was localized in the wasted muscles for ten minutes, and they were then faradized for ten minutes. This was repeated thrice a week for four months, the strength of the voltaic current being gradually increased. At the end of this time the muscles were fairly well developed, and their voluntary power for all movements was restored, though a little awkwardness remained. There was no reaction to less than thirty-five cells of Muirhead's battery, and there was no return of reaction to faradization. No medicine was taken during the treatment. My patient has returned to Africa, armed with an induction and a voltaic instrument, and I have since heard from him that he continues well.

Paralysis. Irritability to Voltaism increased.

In cases of atrophic paralysis from traumatic injury of the nerves, faradization is indispensable. In the cases of men wounded in the civil war in America, it was largely tested in the hospitals of Philadelphia, and the surgeons specially selected for the investigation report as follows :—"The only important means in the treatment of paralysis from default of innervation is faradization by the method of Dr. Duchenne Most of our cases were from

Traumatic Paralysis.

Traumatic Paralysis.

wounds that were of old standing when they came under our care, and localized faradization proved of the utmost value. In some cases, at a single application it restored the power of movement to parts long deprived of it, and we have seen very few instances in which there has not been improved nutrition and greater sensibility and strength when we were able to continue it sufficiently long."* Duchenne reports cases which were of many years' standing, and in which the paralysed limbs were so wasted that the muscles, whose farado-contractility was also abolished, appeared to have quite disappeared. Their sensation and temperature were diminished, the cutaneous veins contracted, and the skin shrivelled, and often purple. Under direct faradization sensation and temperature were quickly restored, the natural colour of the skin returned, the muscles gradually increased in bulk, and regained their voluntary movements, and afterwards their farado-contractility. The following is a typical example.

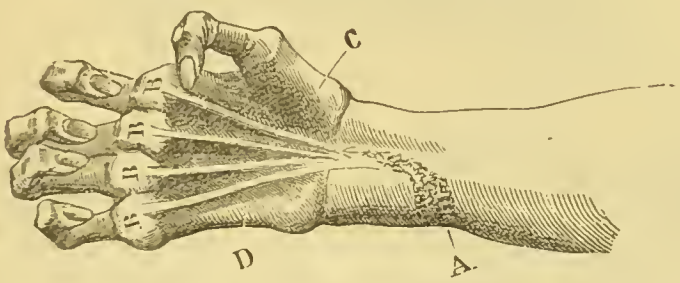
A printer, 19 years of age, was injured on the inner side of the forearm by a cutting instrument, which penetrated about an inch above the metacarpus, grazed the anterior surface of the ulna, and passing within the tendon of the palmaris longus,

* S. Weir Mitchell, George R. Morehouse, and W. W. Keen. "Gunshot Wounds and other injuries of Nerves." Philadelphia: 1868.

lacerated all the tendons in front. The flexor carpi ulnaris, inner fibres of the superficial and deep flexors, the palmaris brevis, and the ulnar nerve and artery, must consequently have been severed. In three months the wound had healed, but the hand was atrophied, and the last two phalanges were rigidly flexed, and in the fourth and fifth fingers could not be mechanically extended, owing to the retraction of the cicatrix (A, fig. 72) to which their

Traumatic Paralysis.

FIG. 72.



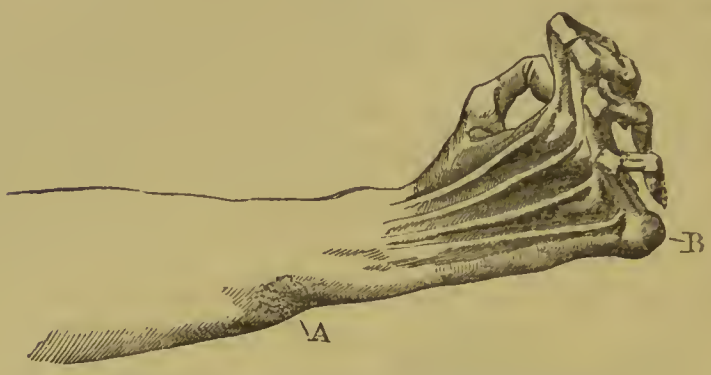
Hand before Treatment. Palmar Surface.

flexor tendons adhered. These bands were ruptured by gradual extension, but complete paralysis remained. Figs. 72 and 73 show the hand before treatment. The injury of the ulnar nerve caused atrophy of the interossei, and the last two lumbricales. The muscles of the forearm were unaffected, and being unopposed, the phalanges were drawn into a claw-like deformity ("*main en griffe*"). This deformity was still more pronounced when the patient endeavoured to extend his fingers. For four years every sort of treatment was tried in

Traumatic Paralysis.

vain. Faradization was then commenced on alternate days, and localized in the interosseous spaces, and the thenar and hypothenar eminences. A

Fig. 73.



Hand before Treatment. Dorsal Surface.

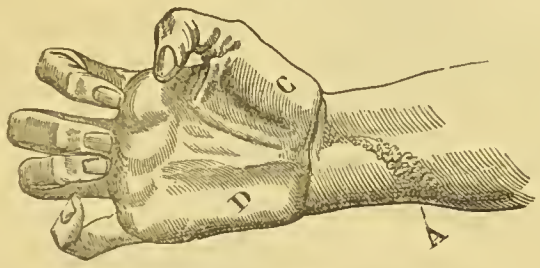
powerful and painful current was used. After ten sittings the patient felt a burning sensation, the hand was observed to be less atrophied, and the interosseous spaces to be slightly filled in, the first phalanges less flexed, and the second began to extend. Circumstances obliged the patient to suspend treatment for three weeks, and when it was resumed the improvement had been maintained. Cutaneous faradization was now added, and sensation greatly improved, and the cutaneous veins, which had not been visible, began to reappear. Development of the small muscles of the hand followed, with improvement in the attitude of the fingers. Next, the heads of the metacarpi ceased to project.

Reckoning on a gradual and spontaneous cure,

the patient again discontinued treatment for two months, at the end of which time he had made no further progress. Treatment was resumed with steady improvement, and gradual return of voluntary power, until he was even able to write. Fig. 74 shows the hand after treatment, as the

Traumatic Paralysis.

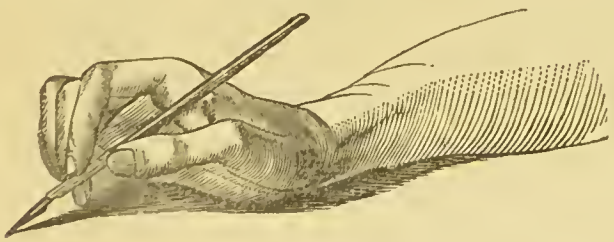
Fig. 74.



Hand after Treatment. Palmar Surface.

patient endeavoured to place it in the deformed position (fig. 72) that it had before treatment. Fig. 75 shows the attitude of the hand when writ-

Fig. 75.



Hand after Treatment.

ing. It will be seen from fig. 74 that he could not succeed in dislocating the first phalanges upon the metacarpi, their old deformity; that the heads of the metacarpi are now in their normal state;

Traumatic Paralysis.

that the flexor tendons are no longer seen projecting in the palm; that the thenar and hypothenar eminences are developed; and, finally, that the fingers have lost their bony appearance.

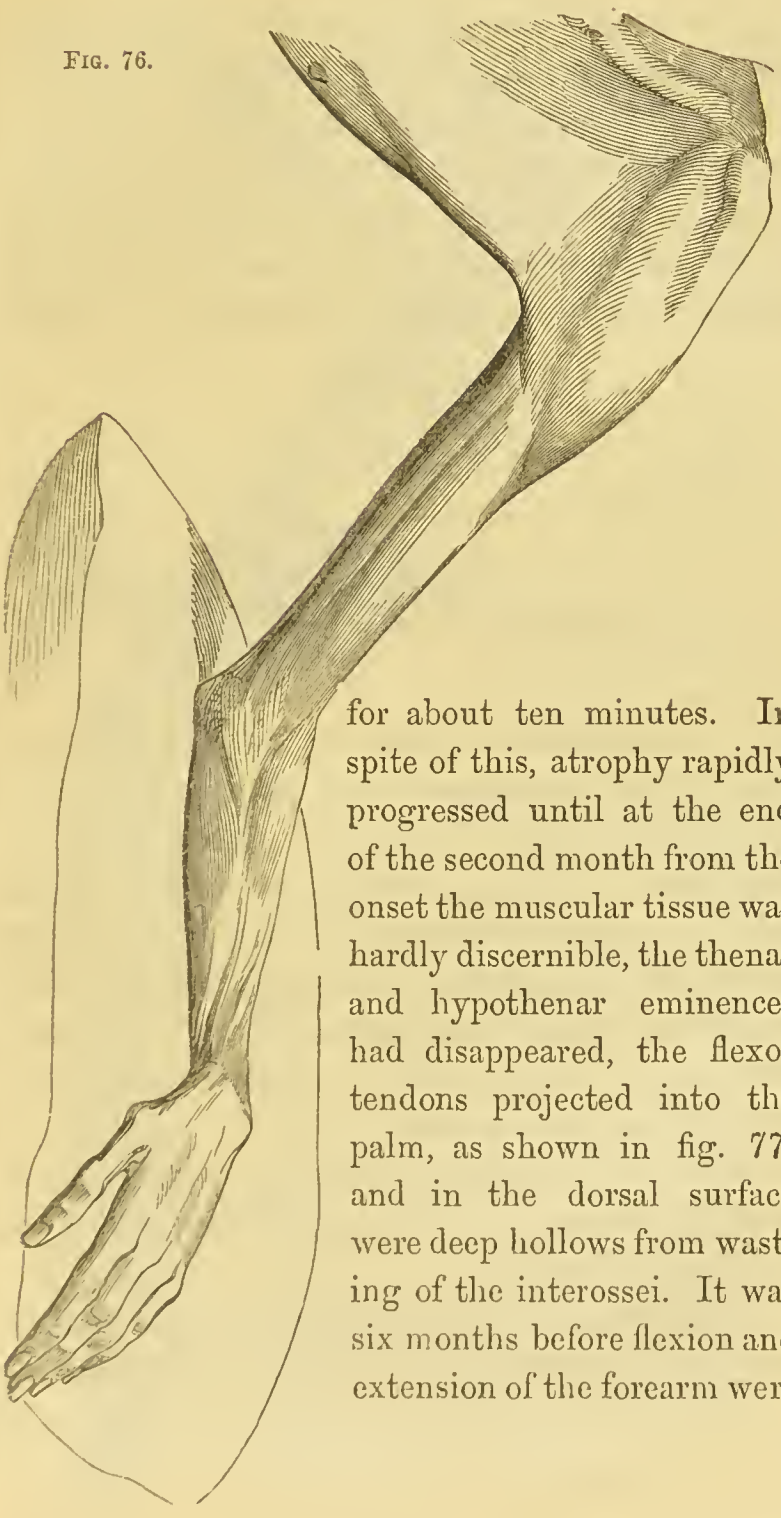
Faradization is only of use *after the nerve has been reunited*, a process requiring time; for it would be irrational to expect benefit as long as the ruptured nerve is physically incapable of transmitting the mandates of the will. Nature will not effect a cure spontaneously by mere lapse of time, for in the above case no less than four years had passed without improvement.

The next case is an example of the inutility in such cases of recent faradization.

A man was admitted into the Hôtel Dieu with a dislocation of the head of the humerus into the axilla. It was reduced under chloroform, when it was found that the muscles of the arm, forearm, and hand were completely paralysed. Sensation was not affected. A month after, when Duchenne first saw the patient his state was unchanged, except that there was considerable atrophy of the paralysed muscles, and sensation was lowered about one-half. Farado-muscular contractility was abolished to either direct or indirect excitation in all the muscles of the hand, forearm, and arm. In the shoulder muscles, the deltoid excepted, in which there was some diminution, it was intact. The muscles were regularly faradized on alternate days

Traumatic Paralysis.

Fig. 76.

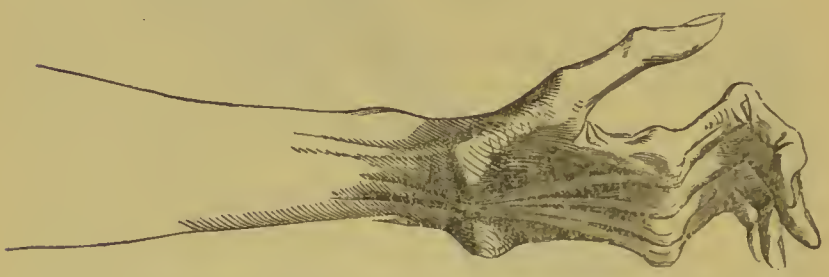


for about ten minutes. In spite of this, atrophy rapidly progressed until at the end of the second month from the onset the muscular tissue was hardly discernible, the thenar and hypothenar eminences had disappeared, the flexor tendons projected into the palm, as shown in fig. 77, and in the dorsal surface were deep hollows from wasting of the interossei. It was six months before flexion and extension of the forearm were

Traumatic Paralysis.

regained, and four years before the development of the muscles again equalled those of the uninjured side. Although there was complete restoration of voluntary power, there was no return of Faradomuscular contractility. Fig. 76 shows the arm one month after the accident, the deltoid is but slightly atrophied, but the arm and forearm are one-third

Fig. 77.



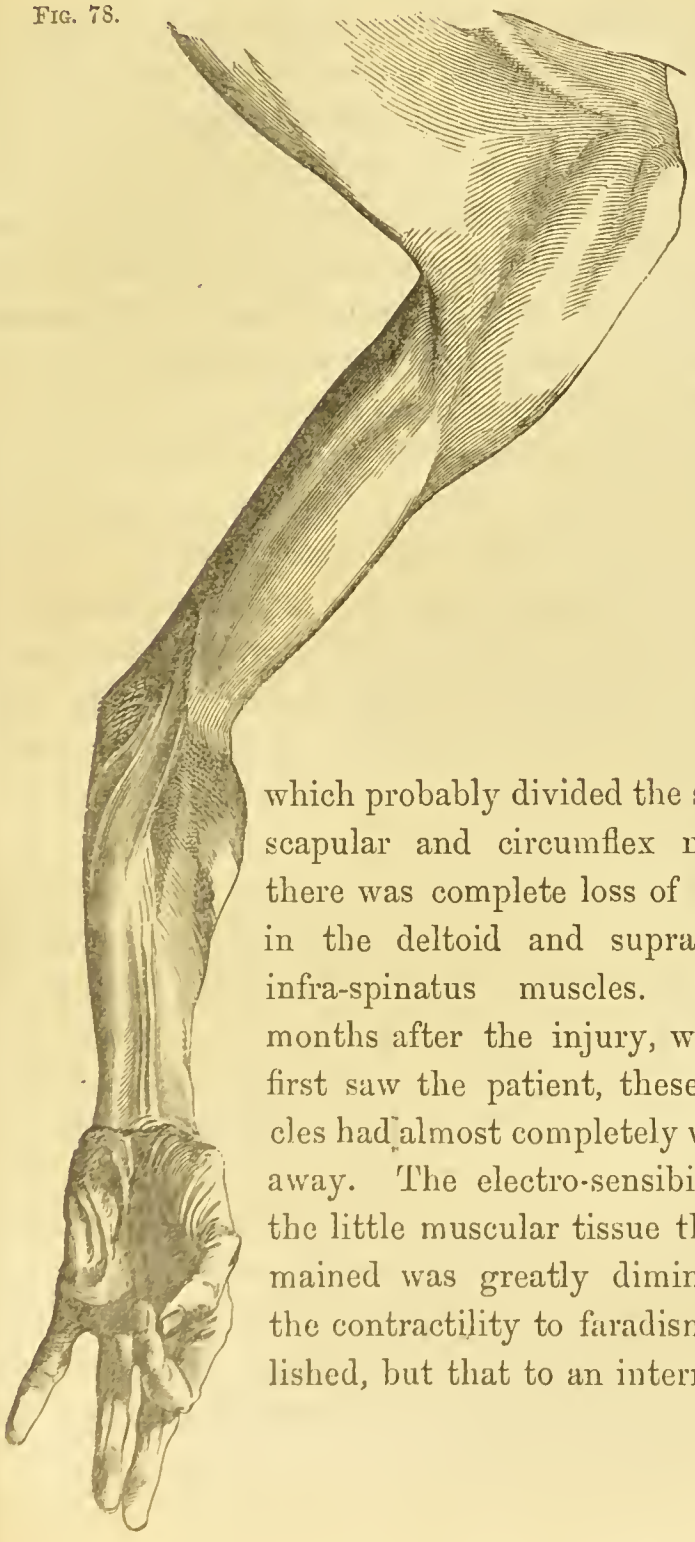
less in circumference than on the uninjured side. Fig. 77 is the palm of the hand two years after the accident. Fig. 78 the arm after the end of treatment. We see then that in traumatic paralysis the regular application of faradism from its onset, does not prevent the muscles from almost complete atrophy; but its use, after repair of nerve lesion, will restore their development, nutrition, and voluntary movement.

But it is in these recent cases of traumatic paralysis that the interrupted voltaic current should be localized in the wasted muscles.

I had under my care a gentleman who was sent to me by Sir James Paget. As the result of a stab,

Fig. 78.

Traumatic Paralysis.



which probably divided the supra-scapular and circumflex nerves, there was complete loss of power in the deltoid and supra- and infra-spinatus muscles. Three months after the injury, when I first saw the patient, these muscles had almost completely wasted away. The electro-sensibility of the little muscular tissue that remained was greatly diminished, the contractility to faradism abolished, but that to an interrupted

Traumatic Paralysis.

voltaic current from thirty cells of the Becker-Muirhead battery was retained. For two months I daily applied the current from fifty cells, holding the sponge from the positive pole stationary upon the centre of the deltoid, and painting, as it were, every part of the affected muscles with the sponge from the negative pole for ten minutes. There was a considerable return of power after three months' treatment; the development of the wasted muscles was remarkable, and the result of the treatment to the extent to which it had then been carried, was most satisfactory. At this period the patient went to Ireland. Daily treatment was continued for four months, when I again saw him and found slight reaction to faradism. The muscles were then faradized and galvanized alternately for about six weeks. I have not seen him since, but he wrote to me in 1874 that he was "quite well."

The following case of traumatic paralysis (also under the care of Sir James Paget) may be cited as an average instance of the amount of benefit to be derived from localized electrization in such cases:—

In September, 1874, a gentleman romping with some children had his head suddenly twisted by one of them to the left side. He fell instantly to the ground without loss of consciousness, but with paralysis of, and loss of sensation in, all four extremities, and also paralysis of the bladder and rectum. Sensation and motion returned after a few days upon the right side, but the left remained

paralysed. When I first saw the patient, nine months after the accident, the muscles of the trunk and of the right upper and lower extremities were normal. All the muscles of the left arm and forearm were wasted, and the deltoid and extensors of the wrist and fingers notably so; the interossei had almost entirely disappeared, deep hollows existing upon the dorsal surface of the hand, while the thenar and hypothenar eminences were quite flattened. The fingers remained semiflexed without any power of extension, and the deltoid was quite powerless. There was slight wasting in all the muscles of the left thigh and leg, and great wasting of the anterior tibial muscles, with inability to extend the toes. Electro-contractility was diminished in all the wasted muscles, but extinct in none. The voltaic and faradic currents were carefully localized in the wasted muscles twice daily—the currents being used alternately. The entire application occupied about twenty minutes, the strength of current used being just sufficient to produce full muscular contraction. After a fortnight's treatment, the power of slight extension of both fingers and toes had returned, and by slow degrees it increased, with, at the same time, progressive development of the muscles. First the patient was able to raise the arm, then to use the hand, and finally, in his own words, "with the exception of a little stiffness in both, especially when cold, it would be impossible to know that there had been anything the matter."

Traumatic Paralysis.

Traumatic Paralysis.

Next, the muscles of the lower extremity slowly regained power and bulk, and he was able to lift the foot and to get upstairs, though with difficulty. Improvement in these muscles was much slower; and now, eighteen months since I first saw the case, there is still considerable weakness.

Infantile Paralysis.

Duchenne strongly advocates faradization in the essential paralysis of infancy, a disease to which he has devoted much attention. Children between the ages of three months and four to five years are liable to suffer from attacks of paralysis differing in many respects from the paralysis of adult life. In infantile paralysis premonitory symptoms are often absent, or but slight, and not seldom the child is put to bed well, and found in the morning to have lost the use of one or more of its limbs; but the visceral muscles are never affected, and the paralysis is motor only, sensation being unaltered. The paralysed muscles soon suffer in their nutrition, the limb affected is found to be much colder than its fellow; and, tested by electricity, there is complete abolition of farado-contractility, but marked increase to the interrupted voltaic current. The muscles begin to atrophy, tend to subsequent degeneration or absolute destruction of tissue, and the final result is often their entire disappearance, the skin literally adhering to the bones, accompanied by deformity or club-foot, from adapted atrophy of the opponents of the paralysed muscles,

but never by rigidity. If proper treatment is adopted *in time*, and before muscular degeneration and atrophy have advanced too far, the greater number of cases of infantile paralysis admit of cure; and where perfect recovery cannot be obtained, we have the great authority of Mr. Adams for the statement, that deformity ought never to result. Mr. Adams writes as follows:*—"By far the larger number of the paralytic deformities we meet with in practice (and these are so numerous as to constitute the great majority of all the non-congenital deformities), will be found to result from infantile paralysis; and I believe that all these deformities may be prevented by judicious treatment—in fact, that there never need be another example of deformity in these cases if the liability to their occurrence and the mode of their production were generally understood."† Infantile Paralysis.

In infantile paralysis the loss of power is usually capricious, so to say, in its distribution, certain muscles, or groups of muscles, only being attacked.

* Club Foot: its Causes, Pathology, and Treatment. By W. Adams, F.R.C.S., &c. 2nd Edition. Churchill, 1873. p. 79 *et seq.*

† The more my experience of these cases extends the more thoroughly do I endorse every word of the above, and the more strongly do I feel how lamentable it is that the physiological treatment of the affected muscles in infantile paralysis has not yet become the routine treatment invariably directed by the practitioner in attendance, and that within a week of the onset of the disease. Were it so an incalculable amount of helplessness and subsequent unhappiness would be spared to children!

Infantile Paralysis.

Sometimes one leg alone is affected, or one arm, less frequently one arm and one leg, and quite as often as not upon opposite sides of the body; seldom both legs, and least frequently of all both legs and both arms. The extensors and supinators of the hand, the deltoid alone, the muscles of the anterior part of the leg, which extend the toes and flex the foot, or the tibialis anticus alone, or the long extensor of the foot alone, may be instanced as common varieties of this form of paralysis. When the leg is attacked, deformities are apt to occur, not from active contraction of the opponents of the powerless muscles, but, as Mr. Adams explains, in consequence of the position assumed by the foot from its mechanical relation to the leg, the antagonist muscles are no longer required of their normal length, nor are they ever called fully into action. They therefore accommodate themselves by a process of adapted atrophy to their required length, and a deformity results, varying, of course, according to the muscles involved in the paralysis, and this deformity depends less upon the number than on the functional importance of the paralysed muscles. The foot is less deformed, and the movements of the leg less affected by the loss of all the motor muscles of the foot than by the paralysis only of certain amongst them. Figs. 79 and 80 are from photographs of a foot all of whose muscles were paralysed and atrophied. The side view,

fig. 80, is almost normal, and in a front view, fig. 79, the only deformity is a less development Infantile Paralysis.

Fig. 79.



Infantile Paralysis.

Fig. 80.



Infantile Paralysis.

than the sound foot. Whereas a single muscle only being atrophied, greater deformity results, as in fig. 81, in which the gastrocnemius alone is paralysed.

Fig. 81.



Infantile Paralysis.

It will be convenient to consider the treatment before and after deformity has taken place. In the first stage of infantile paralysis we have to promote the following results:—To abridge the duration of the paralysis, to prevent if possible, and if not, to arrest or diminish, the wasting and fatty transformation of the muscles, and to prevent deformity. For the first week or ten days after the

Infantile Paralysis.

attack, or for as long as may be necessary, the case must be treated upon general principles, but localized treatment should be had recourse to as soon as possible, and *before the muscles themselves begin to atrophy or to be impaired in their nutrition.* The reaction to electricity of the weakened muscles should be tested, and each muscle should be daily electrized for a few minutes with that current to which it responds, and of a strength just sufficient to produce muscular contraction. Those muscles, although paralysed, whose reaction to faradism is retained, will under its application quickly regain their power.* There is no ground for the feeling of natural repugnance that exists against subjecting children of such tender years, sometimes indeed hardly three months old, to such excitation. Used with slow intermissions, children as a rule betray no sign of pain, if the precaution is taken of gradually inuring them to the strange but not painful sensation which accompanies muscular contraction, and before long the operation even amuses them. As a rule, during the first sitting, I use only

* Careful and thorough electrical examination is of great importance, for while, in an extreme case, all four extremities may be completely paralysed, it may be found that while farado-contractility is quite abolished in some of the paralysed muscles and less so in others, that in some it is normal, and we may confidently predict that these latter will completely recover. On the other hand, the power of certain muscles may be supposed to be retained when it is really abolished, the movements being executed by other muscles. The true condition of the former muscles will be revealed by their electrical reaction.

moistened sponges, and allow no current to pass, and I am always well provided with sugarplums as bribes. In addition to electrization the paralysed limbs should be immersed in water, as hot as can be borne, for a quarter of an hour twice a day, and should afterwards be well rubbed and shampooed, or they may be sponged, before shampooing, in very hot water. It is of the greatest importance that in the intervals of treatment the temperature of the affected muscles should be maintained at as high a degree as possible, and if the leg is affected a stocking of pure spun silk should be constantly worn, day and night, in addition to the ordinary clothing; if the arm, a silken sleeve. At the Children's Hospital I invariably directed the parents to make these of ordinary chamois leather, as a cheap substitute for silk—one for day and one for night wear. When *any* amount of voluntary power has been restored by electricity, it is most important that the child should be encouraged to use the limb, and practise various movements. In every variety of paralysis, as well in adults as in children, it ought always to be remembered that after paralysis the muscles are likely to have forgotten their movements, and, like a child learning to walk, they want instruction. Every paralytic should devote a quarter of an hour twice a day, *even when loss of power is well nigh complete*, to *trying* to make the muscles obey the will. This is a matter that in

Infantile Paralysis.

Infantile Paralysis.

general is far too much neglected. Passive movements are of equal importance, and the mother or nurse must be taught to frequently exercise the paralysed muscles to the *fullest extent* of their normal movements—*e.g.*, if the extensors of the hand and fingers are paralysed the hand and fingers should be flexed and extended completely by the nurse, at intervals of a few seconds, for some minutes; and so on with all the paralysed muscles in succession. If the above directions are patiently and faithfully carried out there are very few cases indeed—if there be any—in which we need fear deformity, and this never until the child begins to walk. If, however, we then observe distortion commencing, the weakened muscles will require mechanical support; but great care must be taken that this support is in nowise allowed to supersede the healthy exercise of the muscles. Many patients in whom deformity has already taken place will yet amend, and this without the necessity for tenotomy; but of course in many cases contracted muscles will require division, but even in these latter the treatment above directed must be assiduously carried out as soon as admissible after the operation.

Mr. Adams details a most instructive case* of a

* Adams, *op. cit.*, p. 293.

boy, eight years of age, who was placed under his care suffering from club-foot, and in whom the deformity had been removed by operation three times previously, at intervals of two years. In Mr. Adams's opinion the relapse had been the result principally of the omission of the physiological means of treatment which had not been directed to be employed. Under proper treatment the form of the foot was restored and the muscular power of the limb rapidly improved. Infantile Paralysis.

But, unfortunately, it is nearly always at a very

Fig. 82.



Paralysis of Muscles of Shoulder and Arm.

advanced period of the paralysis, when all kinds of treatment have been vainly exhausted, that people

Infantile Paralysis.

appeal as a forlorn hope to electrization. The chance of success is less, the later this agency is employed. In those more favourable cases in which voluntary power has returned, the muscles often continue for a long time weak and atrophied. Then a short period of faradization with a current of medium power will often quickly develop them and render their nutrition active. Fig. 82 is an example of paralysis of four years' date, almost completely destroying the muscles of the shoulder and arm. Each muscle was faradized with a

Fig. 83.



Atrophy of Muscles of Shoulder.

Fig. 84.



Muscles developed by Faradization.

tolerably intense current, and this treatment was regularly followed for more than two years. Pro-

gressive improvement was the result, and the deltoid was gradually developed. Fig. 83 is another example of atrophy of the shoulder muscles, and consequent subluxation of the head of the humerus. Fig. 84 shows a shoulder whose muscles had been equally atrophied with fig. 83, but they are now developed by faradization. The relief of the anterior part of the deltoid is manifest, and the well-rounded shoulder forms a striking contrast with figs. 82 and 83. With muscular nutrition voluntary movement also returned. In such cases a satisfactory result can only be expected after long perseverance in the treatment, and even when the absence of visible muscle leads us to fear that its tissue is entirely degenerated, we may hope that a few sound fibres yet remain about which, and from which, it may be possible to develop others, and by their union to form muscular fasciculi, parts of muscles and even entire muscles. But it must be borne in mind that such a result can only be obtained by very long treatment, and it will be useless to begin unless there is the determination to continue the treatment for a year or even for a longer period of time.

Infantile Paralysis.

Fig. 85 is from a striking photograph of atrophic paralysis of the hand. Fig. 86 exhibits the same hand after treatment by faradization.

In common with the degeneration of the muscles, the bones also undergo an arrest of development,

Infantile Paralysis.

adding still more to the deformity. Duchenne has found faradization considerably lessen this shorten-

Fig. 85.



Atrophic Paralysis of Hand.

ing, and even redevelop them. He does not speak favourably of treatment by the interrupted voltaic current. Hesitating, as I cannot but do, to express

Fig. 86.



The same, after Treatment.

an opinion adverse to the conclusions of so distinguished an authority, I am yet convinced that all those cases in *which irritability to this current is increased*, will make better progress under it than under faradization. As a rule, I should advise such cases to be treated at first with the interrupted voltaic current, and subsequently with the

use of the two kinds of currents alternately. In Duchenne's hands the application of voltaism to infants has been attended with unbearable pain. I have not found it so, if only from ten to twenty-five cells of my battery are used, and more are hardly ever required. As soon as there is a return of reaction to faradization, faradization should be solely used. Infantile Paralysis.

Infantile paralysis is almost always a tedious disease, and treatment must be continued for weeks, months, or even years. Parents are apt to bring children to us thus affected with the expectation that after every other remedy has failed, electricity is going to work miracles. The reader is advised always to explain to them the probable length of treatment required, and to decline to have anything to do with the case for a few applications only. Dr. Radcliffe truly says, in Reynolds's "System of Medicine" (the first systematic work, by the way, in which the *primary* importance of electrical treatment in this disease was insisted upon), that "if the paralysed muscles retain their electro-contractility and sensibility, and so show that they have not passed into that state of fatty degeneration into which they always tend to pass eventually, there appears to be scarcely any limit to the time in which improvement and even complete recovery is possible;" and, further on, he adds, "that in all cases the electrical and gymnastic parts of the

Infantile Paralysis.

treatment are of primary rather than of merely secondary importance, I am every day more and more convinced, because every day I meet with instances of muscles which I should once have looked upon as hopelessly paralysed, being resuscitated by these means."

In support of this view of the wisdom of electrical treatment in chronic infantile paralysis, I am able to adduce an instance of what electricity will sometimes accomplish in an apparently hopeless case, and which was regarded as such by myself:—

A child was brought to me in 1869, suffering from a typical attack of infantile paralysis affecting the muscles of the left thigh and leg. Electrical treatment was recommended, but circumstances only allowed of its administration upon three or four occasions, and the child went to India, returning in June, 1875 (after an interval of six years), with a useless leg, measuring some inches less in circumference than the healthy limb, and with a certain amount of deformity. There was complete abolition of reaction to both currents in all the affected muscles, and I was consequently unable to hold out hope of any benefit; but at the earnest request of the mother I instructed her how to use electricity, recommending that she should apply it twice daily, in addition to shampooing.

This treatment has been carried out almost daily, for sixteen months, with a result that is surprising.

Infantile Paralysis.

There is now little difference in the appearance of the two limbs, there is reaction in all the muscles but the anterior tibial muscles of the paralysed limb, and a large amount of voluntary power has returned. The child has been under the joint care of Mr. Adams and myself, and Mr. Adams has succeeded, by mechanical and gymnastic treatment, in curing the deformity. This case forces upon our attention the question, how far it is advisable for the medical practitioner who prescribes electricity to sanction its administration by the patients themselves. It would be practically impossible (to say nothing of the expense to the patient) for any medical man himself to apply electricity daily for fifteen months; and we are compelled, in certain cases, to do our best in instructing *some one attendant of the patient* how to carry out the treatment, making her do this a few times in our presence, *and looking narrowly after her afterwards*, and in addition explaining everything as fully as possible to her mistress. Moreover, we must not lose sight of the fact that, with electricity as with other remedies, the skill of the physician is shown in determining how, when, and in what dose to administer it, and his judgment in selecting those cases in which its administration may be wisely committed to others.*

* The following case of wasted muscles redeveloped occurred in the practice of the National Hospital for the Paralysed and Epileptic. A

Infantile Paralysis.

The subject of electrization in hemiplegia from cerebral disease, and the proper moment for its application, must be carefully considered. Peripheral faradization is seldom advisable until some months after the attack, and then the question arises, whether the persistence of the hemiplegia arises from the muscles having lost their old aptitude of response to the influence of the will, or from the cicatrix or cyst exercising positive pressure upon the cerebral tissue, or from loss of cerebral substance. (I refer to hemiplegia from brain disease, hæmorrhage, or softening.) When there is no rigidity and the muscles are lax, faradization is advisable, for usually the brain lesion is then repaired, and the paralysis is peripheric, and localized in the muscles. Where there is much rigidity, especially with increased reflex action, irritative lesion still persists, and faradization will do no good, and may do harm. But there are many intermediate degrees of lesion that may be benefited; and in almost all cases in which after a spontaneous partial return of voluntary movement, the patient suddenly stops short, and for many weeks or months makes no further progress, faradization comes in, and the

Hemiplegia.

child, six years of age, had from birth been paralysed in one hand, the muscles of which were so wasted that the hand may literally be said to have been mere skin and bone. After seven months' electrical treatment the muscles were redeveloped, power was restored, and, to quote the boy's mother, "He could use his hand to lace his boots."

immediate good that it will then often do is surprising. Half a dozen applications give a fillip to the muscles, and more improvement is often effected in a week than in the preceding year. The improvement is generally sudden. Paralysis. Hemiplegia.

The following is an illustrative case :—

A lady, forty-one years of age, had suffered from right hemiplegia for eighteen months, and described her condition as having remained without improvement for the past six months. She had recovered sufficiently to walk with the aid of a stick, but the movements of the arm were very weak, especially those of the deltoid, extensors of the fingers, and individual muscles of the hand. Faradic contractility was somewhat lowered, but there was no rigidity. The muscles were carefully faradized with a current just sufficiently strong to produce their contraction. The entire application occupied about fifteen minutes, and was made once daily. After a fortnight's electrization she was able to raise the arm to a right angle with the body, and to use the hand to feed herself, neither of which had she been able to do before treatment.

The "late rigidity" of hemiplegia may be largely relieved by electrization. Such a case was not long ago sent to me for electrical treatment, by Mr. Willett, from St. Bartholomew's Hospital. As the result of an accident there had been com- "Late Rigidity."

Paralysis. "Late Rigidity."

pound fracture of the right parietal bone, loss of brain substance and immediate left hemiplegia. The patient was trephined, and after some months' treatment there was considerable return of voluntary power, but with cicatrization there supervened extreme rigidity of the flexor muscles of the left hand, the fingers of which were so tightly contracted that the hands could with difficulty be forced open, and immediately after being opened they reclosed involuntarily. There was also rigidity of the biceps, the forearm being carried semiflexed with inability to further extend it. The continuous voltaic current was localized in the rigid muscles for five minutes, and their antagonists energetically faradized for a second five minutes, three times a week for three months, with the result that at the end of that period the patient could quite straighten his arm, and fully extend the fingers to a level with the back of the hand. In such cases, or whenever a powerful current with little pain is required, Duchenne's pedal rheotome is of great value. By it the current may be interrupted three or four times in a minute, instead of three or four times in a second, which is about the slowest rate of any interrupting hammer of a faradic instrument; and a current sufficiently powerful to penetrate thick muscles may be applied in circumstances under which a very much weaker current rapidly interrupted would give equal pain, and be strong

enough only to act upon the superficial muscular fibres.* Paralysis. "Late Rigidity."

I need hardly remind the reader that always in these electrizations every part of each muscle must be equally excited, as described at page 69, and that it is never necessary to use powerful excitation in any paralysis except when the muscles have lost their sensibility, or when as in atrophy, their nutrition is impaired. Paralysis. During faradization I have never had the misfortune to witness the occurrence of a second apoplectic seizure, and I am confident that faradization skilfully administered has never produced one; but it is wise to remember that all hemiplegic patients are predisposed to a second attack which, if it occurs, is very likely to be attributed to the electrization.†

Dr. Althaus considers that where the clot or softening is of limited extent, the process of reparation in the brain may be promoted or

* My friend Dr. Gowers has improved upon Duchenne's rheotome by having it so constructed that a slight twist of the foot will fix it immovable, and so maintain the current when required without interruption while the foot is removed, which cannot be done with Duchenne's. He has also arranged a pedal commutator of the poles by which the direction of the current may be instantly changed by pressure with the foot. Dr. Gowers' Pedal Commutator can be obtained from Weiss and Co., 62, Strand. It consists of three buttons arranged in a line upon a wooden slab six inches by four. The central button is the rheotome, and the outer buttons the commutators.

† Extra-muscular electrization is chiefly applicable in those cases in which we desire to produce muscular contraction with a minimum of sensation—*e.g.*, in patients who are very sensitive to pain.

Paralysis. Cerebral Electrization.

accelerated by the use of the constant current; and that by this means the parts in the neighbourhood of the paralysing lesion which have become unable to fulfil their function through hyperæmia, serous effusion, or shock, may thus be enabled to regain their function.* He considers that it is absolutely necessary to postpone galvanic treatment until the danger of cerebral fever, which so often follows an attack of hæmorrhage, shall have passed off, and that as this comes on—if it occurs at all—in the second or third week, the application of the voltaic current may be considered safe when from fourteen to eighteen days have elapsed since the occurrence of the attack. If the application is delayed much longer the prospect of ultimate recovery will be diminished on account of the secondary degenerative changes which are apt to come on if the paralysis continues for six months. He advises the galvanization of the injured hemisphere and the cervical sympathetic of the same side, producing anelectrotonus—about three weeks after the occurrence of the attack—commencing with a very feeble current—only one or two cells—and increasing the power slowly and gradually, but not to exceed six or eight cells, to the injured hemisphere, nor for a longer time than two or three minutes; then ten or fifteen cells to

* Althaus's Medical Electricity. Longmans, 1873. Third edition, p. 503.

sympathetic for five minutes. Similar treatment was first recommended by Remak, and it has since been endorsed by Onimus and Legros, Benedikt* and Beard and Rockwell. Althaus states that the result of his own experience has been that, "as a rule, after a few applications, there is greater ease in the head as well as in the limbs; if there has been pain this is relieved, and the motion of the hands and feet becomes re-established." Paralysis. Cerebral Electrization.

Personally, I am of opinion that too much caution cannot be exercised in the application of the voltaic current to the brain when there exists early rigidity, muscular twitchings, or evidence of cerebral hyperæmia; but in those cases in which the paralysed muscles are cold, flaccid, and ill-nourished, and where a generally anæmic type predominates, a carefully administered dose of voltaic electricity to the cerebrum often seems to materially assist peripheral treatment, and I have never seen evil results from such an application.

* The following case occurred in Benedikt's practice (quoted by Althaus):—

A merchant, aged sixty-nine, had an attack of right hemiplegia in August, 1862, with loss of consciousness and language. In May, 1863, the leg had recovered, but all the muscles of the forearm and hand, with the only exception of the muscles of the ball of the thumb, were paralysed, and the flexors and pronators were contracted. Electro-muscular contractility was considerably diminished. The continuous current was applied to the left cerebral hemisphere, and *immediately afterwards* the patient could flex the wrist and fingers. After five more applications he could extend the metacarpo-phalangeal joints fairly well and the phalangeal joints pretty well.

Paralysis.

The ill-nourished muscles in such cases will often benefit largely from being well sponged with the voltaic current, alternately with faradization, and I have seen some more improved by "*Radcliffe's Positive Charge*" than by any other method of electrization. In these cases the general rules laid down under infantile paralysis as to shampooing and gymnastics must never be neglected, but it is important to remember that the exercise should be *short of fatigue*.

Spinal Paralysis.

In the use of electricity in the varying forms of Spinal Paralysis, we must be guided by a consideration of the nature of the disease and the condition of the cord, muscles, and nerves. The evidence in favour of the good resulting from central galvanization of the cord is much greater than can be adduced in support of similar treatment of the brain ; but in both cases the lesions are similar, and I cannot but regard more hopefully the future prospects of cerebral from a careful study of the undoubted good resulting from spinal electrization. The fear of injuring the brain (a fear absent in spinal electrization) has had much to do in limiting our field of observation in brain disease, or a greater number of successes would perhaps have been recorded. Tumours and inflammatory products in the limbs may not seldom be removed by external electrization, probably by stimulating the circulation, improving nutrition, and rendering absorption

more active; and it is not unreasonable to suppose that electrization may promote similar processes (although unseen) in the cord. Be this as it may, a constant voltaic current localized in a diseased cord according to the general principles laid down in cerebral galvanization frequently does much good, and where powerless to cure often relieves some of the most distressing symptoms, and notably those associated with the rectum and bladder. During the early period of active mischief in the cord, peripheral faradization is inadmissible;* but in the persisting localized paralysis following upon myelitis it is often of the greatest service in restoring the nutrition of the limbs. It is in these cases, where electro-muscular contractility is frequently well-nigh extinct to direct stimulation, that indirect faradization of the motor nerves is of the greatest use.† In such cases, moreover, hot

Spinal Paralysis.

Paralysis. Paraplegia.

* But at this stage of the disease, when pain is present and there is tenderness on pressure (and especially when we have reason to suppose that the myelitis is circumscribed), a mild constant voltaic current may be applied, about 10 to 15 cells, positive pole to tender spot, and negative to an indifferent part of the body. It is probable that the absorption of inflammatory products may be promoted by such treatment. At any rate pain will often be lessened by it.

† Dr. Brown-Séquard's experiments prove that after traumatic lesion the cord may be perfectly restored. He divided the cord of a pigeon about the level of the fifth or sixth dorsal vertebra. There was a slight return of power in three months and almost complete recovery in fifteen. The animal was then killed, and on examination it was found, in the author's words, that "*les cicatrices des plaies anciennes de la moëlle épinière renfermaient des fibres nerveuses ayant tout à fait l'aspect normal, et se*

Paralysis. Paraplegia.

localized spongings and shampooings greatly aid electrical treatment. Exercise, if admissible, must be regulated by a general consideration of the case, and it is always contra-indicated during the inflammatory stage. The paralysed muscles should be examined at intervals with the faradic and interrupted voltaic currents, and when it shall have been determined that electrization may be used, one or the other form of current, and at a later period perhaps both currents, should be used according to the suggestions already given. I should be disposed also to charge the patient with positive voltaic electricity after the method of Dr. Radcliffe, or the constant current may be applied in continuity to the spine, or one electrode may be held stationary and the other moved up and down the spinal column, as advocated by Benedikt. These methods are worthy of a trial also in those cases in which, although the cause of the paraplegia may have been removed, the cord itself would appear to have lost more or less of its excitability.*

continuent avec les fibres des parties intactes de la moëlle." Similar results were obtained in several cases. *Brown-Séquard, Comptes Rendus de la Société de Biologie, Juin*, 1851.

* In spinal paralysis all the muscles supplied by nerves originating from the diseased portion of the cord are paralysed and their electro-contractility is diminished, but the paralysis frequently extends to other muscles, and these latter will often rapidly recover under electrization.

The following cases are interesting as illustrations :— Paralysis. Paraplegia.

A gentleman, thirty-seven years of age, consulted me in May, 1876, for loss of power in the lower extremities. One day, after getting very wet, he felt a sensation of "pins and needles" in his right foot, and the feeling gradually extended over both limbs, which, the day afterwards, he found to be "numb," and he became (as he expressed it) "lame." Weakness continued to increase, and when I first saw him, twelve months afterwards, he could just hobble into my consulting room, with the aid of an attendant upon one side and of a stick upon the other. There was considerable anæsthesia in both legs, the muscles of which were flabby, and some constipation and difficulty in emptying the bladder. There was also a spot, tender upon pressure, in the mid-dorsal region. Cutaneous faradization with the wire brush (the current being sufficiently strong to be somewhat painfully felt) was employed once daily for five minutes to each leg, and afterwards, for five minutes more, a sponge from the positive pole of fifteen cells of my battery was held to the painful spot in the spine, while the feet were immersed in a foot-pail of tepid salt and water, in which was inserted a wire from the negative pole. The above treatment was continued daily for a month, and afterwards three

Paralysis. Paraplegia.

times a week for six months. There was marked improvement in a month, and in four the patient could walk across a room without, and for some distance with, a stick. The pain, anæsthesia, and rectum and bladder troubles had all disappeared.

The following case is related by Dr. Poore :—*

"A married man, æt. 37, while in India, at the latter part of 1873, was thrown from his horse, and alighted forcibly on his buttocks and back. Paraplegic symptoms supervened, and failing to get much better he came to England, and was first seen by Dr. Poore in 1874. There was considerable loss of power, though no absolute paralysis, in both legs, but especially the left. He was much troubled by pain like sciatica affecting this leg, by obstinate constipation of the bowels, which acted only at intervals of three or four days, and by an incessant dribbling of urine, which necessitated his wearing an india-rubber urinal. The abdomen was distended apparently by a flaccid condition of the recti abdominalis muscles. These muscles were faradized, and in a very few days the bowels began to act regularly (the constipation having apparently been due to their want of power), and he found himself able to have his trousers and waistcoat, which had been previously

* "A Text-Book of Electricity," by G. V. Poore, M.D., &c., p. 115. Smith, Elder, and Co.

enlarged to meet the increased girth of his abdomen, "taken in." The region of the bladder, and the weakened legs, were also faradized twice a week, and in a month he went into the country relieved of his constipation, his dribbling, and his sciatica, and with very greatly increased power in his legs." Paralysis. Paraplegia.

In that most distressing and intractable disease Cruveilhier's atrophy, or wasting palsy, a combination of localized muscular faradization with Dr. Radcliffe's "positive charge" should always be given a fair trial, the more so as medication is well-nigh useless. In some cases in which I have pursued this plan of treatment there has followed a filling out of the wasted muscles and an arrest of the disease. Localize faradization in the wasted muscles, and vary this treatment on alternate days by the "positive charge." If the disease is in the upper extremities, each hand may be immersed in a separate vessel of brine, the positive pole being placed in one vessel, the negative in the other, and a "ground wire" carried to a chandelier from that containing the negative; or if the lower limbs are affected they may be placed in foot-pails in the same manner, or one arm and one leg according to the localization of the disease. The patient and the battery must be both insulated, the charge as strong as can be borne without discomfort, and the length of application about twenty minutes. Faradize only those muscles that respond to the excitation. To faradize others is Wasting Palsy.

Wasting Palsy.

useless, for in this disease as long as any muscular tissue is left, response to faradism remains and its abolition proves complete degeneration. No electrization can then recall the muscles to life. An apparently hopeless case (reported by Neumann of Magdeburg) began to improve, and ultimately recovered under "Galvanization of the Sympathetic."* Twenty cells were used, the positive pole being held to the nape of the neck, and the negative to the manubrium sterni, close to the border of the sterno-mastoid, for three minutes on each side. The application was made daily for three months and afterwards at less frequent intervals. Before treatment both arms and legs were paralysed, but after a week's galvanism improvement commenced, and in six months the patient was able to walk. In one case that was under my care the disease was arrested by voltaization of the spine combined with faradization of the affected muscles. Atrophy had commenced twelve months previously in the muscles of the ball of the right thumb, and had gradually involved the arm and slightly the shoulder muscles. The thenar and hypothenar eminences and interossei were all so wasted as to render the hand of little use. The muscles affected were faradized daily for ten minutes with a current just sufficiently powerful to produce full contraction,

* Berliner Klinische Wochenschrift, Sept. 14, 1868.

and the voltaic current was localized in the spine for fifteen minutes every night at bedtime. The positive pole, from 15 to 25 cells of my battery, was held stationary to the nape of the neck, and the negative pole "painted" down the spine from the position of the positive to the sacrum. This about twice per minute. There was considerable improvement in six weeks, especially in the muscles of the hand, and after four months' treatment the power and bulk of the muscles had much increased, there remaining only slight weakness and some awkwardness in their use. The improvement was maintained, but further electrical treatment did not increase it. Wasting Palsy.

The following is a remarkable example of the benefit of electrization in muscular atrophy. An Indian officer fell from his horse in May, 1873, striking the back of his head. He was stunned, but recovered in a few minutes, remounted, and rode home. About a month afterwards he noticed that his right arm was getting weak, and this weakness slowly increased. At the end of four months he found that his right leg was colder than the left, that he was "catching his toes," and that he could not "grip" the saddle when riding. Under treatment the weakness of the leg disappeared, but the arm became more powerless, and in six months he noticed that it was wasting. This continuing in spite of treatment, he determined to come to Eng-

Wasting Palsy.

land, and brought me a note from a brother officer who had been under my care. Upon examining him (June, 1875) I found that all the muscles of the arm and forearm were atrophied (the affected arm measuring two and a half inches and the forearm one and three-eighth inches less than the corresponding points of the healthy limb). The hand was considerably wasted, but its normal movements were retained, though they were very weak, the grasp of the hand being barely felt. The deltoid and shoulder muscles were also much atrophied, and the muscles of the right half of the thorax seemed slightly less developed than the corresponding muscles of the sound side. There was some fibrillation, and electro-contractility was slightly lowered to both currents. The patient complained of a constant feeling of cold in all the affected muscles. The muscles were carefully faradized twice daily for five minutes *with a current just sufficiently strong to produce their contraction,* and three times a week I galvanized the sympathetic on both sides for five minutes each, using fifteen cells of my battery, a large sponge from the negative pole being held to the seventh cervical vertebra, and a small leather-tipped conductor from the positive poles inserted into the ariculo-mastoid fossa. In a month there was improvement and the feeling of cold had disappeared, while there was less flabbiness of the muscles. At the end of two months there was distinct filling-out

of the wasted muscles, and faradization was from this date continued but once daily. At the end of three months galvanization of the sympathetic was given up, and faradization used only three times a week. From this date improvement steadily increased, and when I last saw my patient upon his return to India the movements of the right limb were completely restored, and its development nearly equalled that of the left.* Wasting Palsy.

Hysterical paralysis, whether accompanied by anæsthesia or hyperæsthesia, will frequently be removed by cutaneous faradization with the wire Hysterical Paralysis.

* The following is an extract from Dr. Sturge's Report of the results of treatment at the National Hospital for the Paralysed and Epileptic during 1876 :—

"In the division of Muscular Atrophies some striking cases have occurred, and in all of these the improvement is mainly due to the electrical treatment prescribed.

"A patient, with atrophy of some of the muscles of both arms of six months' standing, which incapacitated her from dressing herself or cutting her food, or doing much household work, was discharged at the end of three and a half months, able to feed and dress herself, sew, and perform almost any domestic duty.

"Another woman, with atrophy of the muscles of the forearm of several years' standing, and who was similarly incapacitated from almost all use of the hands, went out, after a month's treatment, able to dress and feed herself, and to perform many actions that were before impossible for her.

"A man came to the hospital with atrophy of many muscles in various parts of the body, more especially in the left arm, which he was unable to move from the side. He went out able to lift his arm well over his head, and with much increased strength in the limb.

"Another man, in a very similar condition, was also greatly benefited; and whereas on admission he could barely bend the right arm at the elbow, after three months' treatment he was able to use a hammer with the arm."

Hysterical Paralysis.

brush, or by localized muscular faradization.* In most cases while contractility is intact, sensibility is abolished or diminished (a valuable diagnostic sign of hysterical from cerebral hemiplegia). If electrization proves of benefit, it will usually do so in two or three sittings, and it is as a rule useless to continue beyond half a dozen if there is then no improvement. The treatment must be localized in each of the affected organs, and continued some time after return of movement, so as to fix, so to say, the cure. In hysterical contractions, as of the fingers, on account of the extreme excitability of the cord, faradism may do harm. Dr. Radcliffe's positive charge should be used. In those cases in which there is excessive localized sensitiveness, which is not lessened either by cutaneous faradization or voltaization by sparks, I have occasionally found benefit from the constant current, one electrode on the painful spot, and the other as near as possible to the nerve origin, with as powerful a current as the patient will submit to. I refer only to hysterical hyperæsthesia, not to neuralgia.†

* In one of Duchenne's cases the patient, who was paraplegic, had kept her bed for six months. Muscular faradization had been employed without benefit. The skin being anæsthetic, Duchenne used the wire brush, and after one application the patient got up and walked.

† Some instances of undoubted emotional paralysis are most obstinate, and unless they speedily benefit from electrical treatment they will often tax the resources of medicine to the uttermost. It is unwise to undertake the care of such cases with an expression of great confidence, for the proverb of pride going before a fall has good chance of being verified when this is done.

Local Paralysis.

In all cases of local paralysis which are dependent upon blood poisoning, such as mercurial and lead palsy, electrization is never to be neglected. In most cases, even those which have resisted the most energetic prior treatment, a combination of the interrupted voltaic current and faradization, alternately localized in the affected muscles, will triumph over the disease. The current must be sufficiently powerful to cause pain. Such cases are tedious, requiring from twenty to fifty sittings.

Lead Palsy.

In lead palsy the muscles that most frequently suffer are the extensor muscles of the upper extremities, and notably the extensor communis digitorum, the paralysis of which causes the "drop wrist," so common among painters and workers in lead. The supinators always escape. The deltoid and triceps suffer next in frequency; but it is comparatively seldom that the muscles of the lower extremities are included in the paralysis. The "blue line," and the other symptoms of lead poisoning, should always be looked for, and sulphur baths and iodide of potassium administered; but although the lead may be eliminated from the system by these remedies, there is often no return of power in the paralysed muscles, unless electricity is localized in them. The mischief seems to begin in a nutritive degeneration of the muscular tissue; but electrical examination frequently detects certain muscular fasciculi to be

Lead Palsy.

more deeply affected than others of the same muscle, and enables us to chiefly localize treatment in these fasciculi. There is almost invariably diminution or complete abolition of irritability to faradism, and at the earlier stage of the disease increased reaction to the interrupted voltaic current. Shampooing and appropriate gymnastic exercises should be also made use of.*

The following is an example of lead palsy, occurring in hospital practice. The case was under the care of Dr. Bastian, and the notes were taken by Dr. Sturge. The patient was a painter, twenty-nine years of age, who had had three attacks of lead colic, the last of them two years ago, but no previous attack of palsy :—

Six months before he attended at the hospital he began to notice weakness in the arms; they appeared stiff, and were rather painful, so that he thought he had rheumatism in them. During the two months preceding his admission into the hospital the weakness had grown rapidly worse, and he now found for the first time that it was the forearms which were affected. The right wrist was the first to assume the "dropped" position, the left following rather later.

* Dr. Garrod informs me that patients suffering from gout are peculiarly susceptible to the poisonous influence of lead, and that he has known cases of "drop wrist" in gouty subjects traceable to their drinking water contaminated with lead, and which failed to induce the disease in other and healthy persons.

Lead Palsy.

On admission, it was found that the right wrist had "dropped" to the full extent; the hand, during pronation, formed a right angle with the forearm, and extension of the wrist was impossible. The left arm was not affected to the same extent, and he could extend the wrist so that the hand was in a straight line with the forearm. The supinator longus on both sides acted fairly well.

Tested electrically, it was found that the extensors of the wrist, the fingers, and of the thumb on both sides had completely lost reaction to faradization. There was some diminution in the reaction to voltaic electricity in some of these muscles on the right side. On the left side the voltaic reaction was normal. There was a faint blue line on the gums. The patient was ordered five grains of iodide of potassium three times a day, and to have voltaic electricity applied to the back of the forearm three times a week.

He was under treatment for about six months, by the end of which time he had very much improved. He could extend the left wrist nearly to the full extent, and the right until the hand was considerably beyond the line of the forearm.

Rheumatic Paralysis.

In the local or partial paralysis of muscles, which not uncommonly results from exposure to cold, the farado-muscular contractility is usually intact. Rheumatic paralysis of the musculo-spiral nerve may be cited as an example. This is liable to be

Rheumatic Paralysis.

confounded with lead palsy. In both diseases the same muscles may be affected—the extensors of the hand and fingers. In lead palsy the supinators are not paralysed, and farado-contractility and sensibility are diminished or abolished, but in paralysis from cold while the supinators suffer, electro-contractility is normal, and the sensibility may be increased. The only exception to this rule is in facial paralysis from cold, where the farado-contractility is diminished, or absent, and this diminution may perhaps be explained by the fact of the facial nerve traversing a bony canal (the aqueductus Fallopii), where, if the nerve swells, it is compressed.

Paralysis of Musculo-spiral Nerve.

For the following example of the benefit of electrization in a case of paralysis of the musculo-spiral nerve from pressure, I am indebted to Dr. Gowers, and for the notes to Dr. Sturge. It will be seen that there was marked paralysis in the supinators, which in the case just quoted of lead palsy were intact. The patient was a carpenter, fifty-three years of age, who had never worked in lead. He began to attend the National Hospital for the Paralysed and Epileptic in September, 1876. The history was, that between four and five weeks previously he went to sleep, when half drunk, sitting in a chair, with his right arm resting on the top of an iron fireguard. When he woke up, after having remained in this position for two or three hours, the arm was numb from the elbow

downwards, and the hand felt rather weak. He had no difficulty in undressing himself, and by the time he was in bed the numbness and weakness had diminished. On waking next morning the arm was again quite numb from the elbow downwards, the wrist was dropped, and the grasp of the hand weak. The weakness remained, but the numbness went off. On admission, the wrist was completely dropped, and he had no power of extending the first phalange of the fingers. If the first phalanges were extended by the help of the other hand, he could then flex and extend the second and third phalanges at will, and with good power, by means of the interossei, which were unaffected. There was very marked paralysis of the right supinator longus, and the supinator brevis was much weakened.

Paralysis of Musculo-spiral Nerve.

He felt the slightest touch on any part of the forearm or hand, but if the back of the forearm, or of the thumb, were rubbed with some force, he experienced a sort of numb sensation, with slight pins and needles. When he first began to attend at the hospital the difference in reaction on the two sides to the two currents was very slight; but a week afterwards there was a diminution of reaction to faradization in the paralysed muscles amounting to about two degrees of the graduator in Stöhrer's large battery; that is to say, the paralysed muscles required the graduator to be raised two degrees

Paralysis of Musculo-spiral Nerve.

higher to produce the first signs of contraction, than was necessary for the corresponding muscles on the healthy side. If a strong current, however, was used the hands on the healthy side contracted much more vigorously than those on the diseased side. There was also some diminution of reaction on the paralysed side to the voltaic current, the difference on the two sides amounting to six cells of Stöhrer's battery.

The patient was treated with voltaic electricity, the positive pole being placed just above the elbow, and the negative swept up and down the back of the forearm. The electricity was applied three times a week, each sitting lasting from ten minutes to a quarter of an hour. The current employed was a strong, but not painful one—that produced from sixteen to twenty cells of Stöhrer's battery. By the end of November he had very much improved; he could lift the hand up to considerably above the level of the wrist, and the power of extending the fingers had in great measure returned. He continued to attend for a few weeks longer, when he was discharged nearly well. The paralysed muscles recovered the normal irritability to faradization as they improved in power.

Facial Palsy.

Facial paralysis may almost always, even after it has been stationary for many months, be cured by voltaization and faradization, but much more quickly where the farado-contractility remains. The

muscles must be treated by that current to which they respond, but with faradization it is especially necessary on the face that the *direct* should be preferred to the *indirect* application. In almost all cases the muscles recover unequally; reaction returns in some before others, *although supplied by the same nerve.* The excitation must then be localized more in the backward muscles, or a deformity may result.* In the most favourable cases an unnatural expression of countenance will generally persist for a long time, from the non-recovery by the muscles of their perfect "tone," that quality which imprints upon each face its characteristic features, and which has been called the "gymnast of the soul." Few patients will submit long enough to electrical treatment to obtain perfect regularity upon both sides of the face. Any spasm or fibrillation following faradization, or any artificial excitation, is a warning of threatening tonic contractions of the muscles, and faradization must be at once discontinued, or deformity will result. Such cases make good progress under Dr. Radcliffe's positive charge, applied daily. I had under treatment a case of right facial paralysis of twenty-three years' standing. Before the patient was placed under my care there had been, from energetic faradization, considerable

Facial Palsy.

* I have several times succeeded in removing a contraction which had been produced by too powerful faradization by passing a constant voltaic current from ten cells of my battery through the contracted muscle.

Facial Palsy. improvement, but incessant muscular fibrillation remained. Under daily treatment with this positive charge the fibrillation disappeared, and there was also much increase of power in the paralysed muscles.

For notes of the following example of the benefit of early electrical treatment in peripheral facial paralysis, I am indebted to Dr. Sturge :—

The patient had been subjected to much worry and anxiety for some time, but had had no definite ailment until the early part of June, 1876, when one morning, about an hour after getting up, she felt as though the right eye was "going to have a cold in it." It was painful, and watered a good deal. Her husband looked at it, but could not detect that anything strange had occurred. On sitting down to dinner, however, she found that she could not drink nor eat properly, because, as she said, "she could not move her lips into the proper position." She had had no headache nor earache, nor discharge from the ear ; neither could she recollect that she had been exposed to a draught. She had no numbness of the face. The pain in the eye continued for two days, and the light was painful to her.

She first came up to the National Hospital about a fortnight after the onset, and there was then marked facial paralysis. She was unable to close the right eye, and the right angle of the mouth

was retracted much less than the left when she showed her teeth. Her taste was unaffected. In other respects she was quite healthy. Facial Palsy.

When the face was tested electrically, there was found to be marked diminution in reaction to the induced current on the right side, amounting to about four degrees on the graduator of Stöhrer's battery, as compared with the corresponding muscles of the healthy side, this difference being seen whether the rheophore were applied over the facial nerve or over the muscles themselves. To the voltaic current there was a difference in reaction according as the rheophores were applied over the nerves or over the muscles themselves. When applied over the nerves, the muscles reacted to six cells on the healthy, but only to eight on the diseased side. When applied over the muscles themselves, contraction was seen with six cells on the healthy, and with four on the diseased side. There was thus present the typical degenerative reaction which follows when a nerve trunk is involved in a grave lesion—viz., diminution of faradic irritability through both nerve and muscle, diminution of reaction to the voltaic current when the rheophores are applied over the *nerve*, and increase of reaction when they are applied over the muscles themselves.

She was ordered the voltaic current, to be applied on the paralysed side three times a week, and to be followed at each sitting by the use of faradic

Facial Palsy.

electricity. The voltaic current used was that from about six of Stöhrer's elements; the faradic, such as would produce moderate contraction of the muscles without giving great pain. After a month of this treatment, the patient was discharged nearly well, the difference in electrical reaction on the two sides being very much less marked.

As an instance of what electricity will sometimes accomplish in long-standing cases, the following is of interest:—

A young lady, fourteen years of age, had suffered from birth from right facial paralysis. Her mother had been four days in labour, and the delivery had been effected with instruments. I saw her for the first time upon June 7th, 1876. She was then unable to close the eye, or to frown, or to raise the angle of the mouth. Reaction was greatly diminished to both voltaic and faradic currents, but not abolished. The muscles were sponged with very hot water for a few moments—just long enough to redden them; they were then thoroughly kneaded and shampooed for ten minutes, and faradized for five minutes with a current just sufficiently powerful to produce muscular contraction. For the first week this treatment was carried out twice daily; afterwards once daily. In a month the patient could partially close the eye, and treatment was then directed to be employed three times a week only; but the patient was advised to sit in front of

a looking-glass, and practise movements of the weakened muscles for ten minutes twice daily. Improvement was progressive. In three months she could wrinkle her brow, and slightly raise the angle of the mouth; and in six months the recovery of voluntary power was almost complete. The eye could be firmly closed, and there was no distortion of the mouth when speaking, and but very slight when laughing. Facial Palsy.

There are several other strictly local palsies that may be successfully treated by electrization, as, for instance, paralysis of the muscles of the eye, when the disease is not the result of central lesion. One pole must be placed over the facial nerve below the ear, and the other applied to the closed eyelid for about twenty seconds, the entire application lasting about five minutes. Paralysis of Muscles of Eye.

In such cases Mr. R. Brudenell Carter has recommended tenotomy of the contracted, and faradization of the paralysed, muscle by direct application to the conjunctiva. This is an exquisitely painful application, and I have found few patients who will submit to it, while in the majority of cases the above far less severe procedure is equally efficacious. Similar treatment is required in mydriasis or dilated pupil from paralysis of the iris, a very troublesome affection on account of its interference with the sight by admitting too much light to the retina. If, however, direct applications be

Paralysis of Muscles of Eye.

made to the conjunctiva, see that the margins of the eyelids do not touch the stem of the rheophore, or severe spasm will result. To avoid this, pinch up the skin of the eyebrow between the thumb and finger, and so retain it during the operation. A very excellent method of electrizing the muscles of the eye is for the operator to use the forefinger of his right hand, covered by a finger-stall of wet linen, as an electrode, passing the current through his own body by holding the sponge-holder from one pole, not by its insulating handle, but by its moistened sponge in contact with the palm, in his left hand, the conductor from the second pole being similarly held in one of the hands of the patient. This application is not only convenient, but it is calculated to allay the fears of a sensitive patient; or a pointed conductor covered with wet leather may be connected with the one pole, and its point held immovable and firmly pressed down upon the orbital margin, as near as possible to the position of the muscle it is desired to excite, while the patient touches at intervals the sponge from the second pole held by its insulating handle in the operator's disengaged hand.

Amaurosis.

Certain amauroses depending upon torpidity of the optic nerve may be removed or greatly lessened by a daily application of the interrupted voltaic current, the special action of which upon the retina has been already set forth. The directions above

given for faradism apply equally to voltaization: but as these amauroses are symptomatic of essentially different conditions, the ophthalmoscope must always be first employed for their diagnosis. A successful case has been reported by Dr. Pye-Smith. Both optic disks were white, and their vessels small and few in number. Both eyes were galvanized three times a week for eight weeks, the positive pole from twenty cells of Muirhead's battery being held to the mastoid process, and the negative to the brow or closed eye of the same side. The current was allowed to pass for eight or ten seconds, and this was repeated about six times at each sitting. Before treatment the patient could just see the windows of the hospital ward, but he could not count the panes; after the fourth application he could see seats in the grounds; after the seventh he could count the window panes; and after the seventeenth he could read "Operation Room" painted over one of the doors in letters about three inches high.* Amaurosis.

In a case under my own care, in which there had been much weakness of the eyes since a blow upon the forehead three months before from a cricket ball, electricity perfectly restored the sight. There was considerable photophobia and lachrymation, and a course of tonic medicines and six weeks at

* *British Medical Journal*, May 18, 1872.

Amaurosis.

the sea-side had failed to be of benefit. The ophthalmoscopic appearances were normal. Ten cells of Muirhead's battery were applied daily for five minutes—positive pole stationary to nape of neck and negative held to each closed eye alternately for about thirty seconds—that is, about five applications to each eye. Then negative pole to nape of neck and positive held stationary in auriculo-maxillary fossa for five minutes on each side. In a week the patient was able to discard his eye-shade when in the house, and the photophobia and lachrymation were much less. Improvement was progressive, and in five weeks—during the latter two of which electricity had only been applied upon alternate days—recovery was complete.

Deafness.

Faradization is sometimes of service in nervous deafness, that variety of deafness in which no organic lesion can be discovered by the aurist, and which is frequently extremely intractable to medical treatment. Duchenne quotes cases that had existed from two to twenty years, and in which a perfect and permanent cure resulted after from fifteen to thirty applications made as described at page 105. Commence with the lowest power of the instrument, and with about two intermissions in each second. Never make the application *without using the pedal rheotome*, and increase the power gradually until a distinct sensation a little short of pain is felt either in the meatus itself or in the tongue.

Be careful that the conducting wire of the rheophore does not project beyond its insulating cylinder and touch the mucous membrane of the meatus, or acute pain will be caused. Faradize on alternate days for about five minutes. Should the least giddiness occur, discontinue instantly, and lower the strength of the current. In certain cases of congenital deaf-mutism, not depending upon any anatomical lesion, the trial of similar treatment is advisable. Hysterical deafness, even of many months' duration, is usually quickly removed in from two to six applications. Duchenne, by faradization, succeeded in almost entirely curing a case of deaf-mutism in a boy eight years of age who had been deaf and dumb from birth, and who before treatment could not hear loud shouting. After the seventh application the boy heard words pronounced close to his ear, and after the twentieth could say "papa" and "mamma." Improvement was progressive, and after a year the boy read easily and asked for everything that he wanted. Deafness.

Brenner of St. Petersburg has reported two cases improved, one as much improved and one as cured, by the application of the interrupted voltaic current, and in all cases this method of treatment should be tried before the patient is pronounced incurable.*

* Tinnitus may often be relieved by voltaization of the auditory nerve, and where this fails galvanization of the sympathetic may be resorted to.

Glosso-labio-laryngeal Paralysis.

In *glosso-labio-laryngeal paralysis* faradization of the tongue and of the muscles of the pharynx will improve for a time the articulation of words and the deglutition. One pole is to be applied to the nape of the neck, and the other in succession to all parts of the tongue and lips that are wasted, and externally, with a powerful current, to affect the pharynx. The application of the interrupted voltaic current will sometimes produce great though only temporary improvement. The positive pole should be held to the back of the neck and the negative well painted over the affected muscles.

Locomotor Ataxy.

In *locomotor ataxy* faradization, while powerless to cure, is one of the best palliatives. By its application the diplopia, a common symptom in the first stage of the disease, is for the most part removed for a time, to the great comfort of the patient. The distressing muscular pains will often diminish or even disappear under cutaneous faradization, as also the muscular and cutaneous anæsthesia* which greatly add to the troubles of co-ordination, and upon the diminution of which a marked improvement in locomotion generally results. At an early period of the disease the constant voltaic current to the spine—both poles stationary—may be

* Faradization with the wire brush often acts like a charm in removing anæsthesia, which although originally of central origin continues after the removal of its cause. Anæsthesia from section of a nerve is sometimes persistent in this way after repair of the nerve lesion.

tried. In one case under my care its use resulted in perfect recovery, while in several other cases it has relieved many of the symptoms. In the case referred to the ataxy had existed for eighteen months, the gait being most characteristic and the patient unable to walk without assistance. There was also considerable anæsthesia, which was treated by faradization with the wire brush. The current from fifteen to twenty cells of Muirhead's battery was applied to the spine by large sponges (the sponge-holders being five inches in diameter), the positive sponge to the nape of the neck and the negative to the lower lumbar vertebræ, both sponges held immovable for ten minutes, followed by five minutes' faradization by the wire brush to the legs and feet. These applications were made daily upon getting up and going to bed. The patient had improved in one month, he could walk without assistance in three, and in eight he was apparently quite well. I then lost sight of him, but I have no doubt I should have seen him again had he not remained well. Locomotor Ataxy.

In all cases in which tremor or spasm is a prominent symptom Dr. Radcliffe's positive charge holds out promise of the happiest result. If during the time of the charge the tremor ceases, the prognosis is the more favourable. From this treatment I have had good results in several cases of spasmodic wryneck (torticollis) from contraction of the sterno- Tremor. Spasm.

Tremor.

mastoid, splenius or clavicular portion of the trapezius, or of some deeper-seated muscles. In these cases it is always advisable to combine with the charge energetic faradization of the antagonists of the contracting muscles; and the same treatment may be followed with advantage in writer's cramp and analogous affections, especially when conjoined with appropriate gymnastic exercises of the affected muscles alternating with periods of perfect rest to them.

Writer's Cramp.

In writer's cramp, which consists essentially of a paroxysm of spasm whenever the sufferer is called upon to execute some special movement, but in which there is no true paralysis, Dr. Poore has very successfully applied the refreshing and restorative effects of the *constant* voltaic current by localizing it in the nerves of the affected muscles, and exercising these muscles *during the passage of the current* by various gymnastic movements. I have been successful in two cases by faradization of the antagonists of the suffering muscles, united with the localization in the muscles themselves of "Radcliffe's Positive Charge" for fifteen minutes daily.*

Torticollis.

Fig. 87 is an instance of torticollis, from spasmodic contraction of the right trapezius, of thirteen

* In all cases of supposed Writer's Cramp, the muscles should be functionally examined to see whether they retain their normal movements; whether, in fact, the case is not one of paralysis with nerve irritation. The question of anæsthesia should be specially investigated, and if it exists the wire brush should be used.

months' duration. The patient was a girl. The head was inclined towards the right shoulder, and Torticollis.

Fig. 87.



Torticollis.

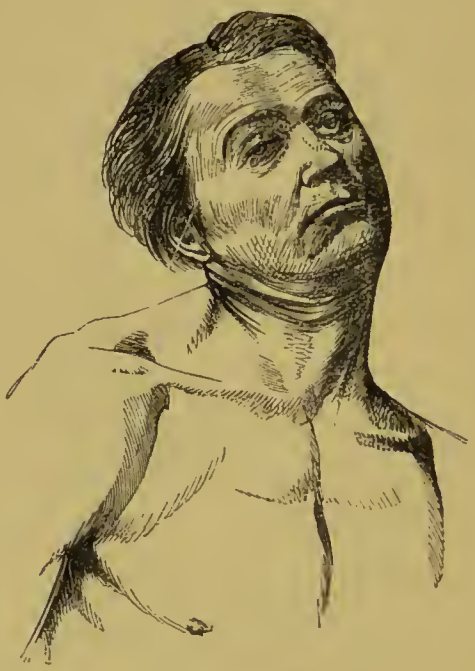
slightly towards the scapula. She could bend the head but very little forwards, and not at all to the right, and trying to do so caused acute pain in the back of the neck near the upper attachment of the right trapezius, whose rigid tendon could be seen and its resistance felt. The prominence of the sterno-mastoid could be artificially caused on the right side by faradization. Localized faradization of the clavicular portion of the trapezius of the opposite side resulted in a perfect cure.

Fig. 88 represents a case of contraction of the splenius. The symptoms were inclination of the Contraction of Splenius.

Contraction of Splenius.

head backwards and towards the contracted side, with swelling of the splenius sensible to the touch.

Fig. 88.



Contraction of Splenius.

Faradization of the antagonist splenius entirely removed the deformity.

Chronic torticollis is a most obstinate affection, as it not unfrequently depends upon organic disease. The younger the patient the more hopeful the prognosis. One of the most successful results of electrization in spasmodic torticollis was the case of a young lady, twenty years of age, who was sent to me by Sir James Paget. The spasm was almost constant, and had existed for twelve months, having

resisted every kind of treatment, including hypodermic injections of morphia and the wearing of a mechanical apparatus. There was some wasting of the sterno-mastoid and trapezius on the right side, and the corresponding muscles of the left side exhibited increased irritability to all forms of electricity, and were the seat of some pain and almost constant clonic spasm. The voltaic current from twenty cells of Muirhead's battery was localized in these muscles by stationary sponges for fifteen minutes night and morning, and *at the same time* the opposite muscles were well faradized. In a week there was slight improvement, and the patient was then directed to sit in front of a looking-glass, and to try to bring the head into the normal position, in time with the counting "one, two" of a bystander. After a month's treatment improvement was more rapid, but it was six months before recovery was complete. In another case, that was sent to me by Dr. Radcliffe, recovery was equally complete, but treatment seemed to be materially aided by the hypodermic injection of arsenic.

Contraction of Splenius.

It is hardly necessary to say that spasmodic affections, such as paralysis agitans, caused by degeneration of the nervous centres, cannot be cured by electricity; but in functional affections, arising from slight local irritation or from debility, such affections as Dr. Poore graphically designates "fatigue diseases," its use is of the first importance.

Contraction of Splenius.

The following is an illustrative case:—A gentleman, forty-four years of age, who for some time had been in weak health, but without the existence of any special disease, had, he informed me, for nearly two years, suffered from increasing trembling of the right arm, which he declared was never sufficiently steady for him even to sign his own name. On his attempting to do so in my consulting-room, the spasm was so violent that his hand moved all over the paper, and he broke the nibs of a steel pen. He could not even dip a pen in the ink. When at rest, there was no spasm. The muscles were fully developed, their electrical reaction was normal, and he was able to execute with some difficulty all other movements but writing. He was treated twice daily, upon getting up and going to bed, with "Radcliffe's positive charge" from twenty cells of my battery for fifteen minutes, the hand being immersed in water with a wire from one pole, and a sponge from the other applied to the back of the neck. There was considerable improvement in a week, and recovery was complete in six weeks.

Athetosis.

The only recorded case of improvement in that remarkable condition of spasm, first described by Hammond under the name of athetosis, resulted from the application of the voltaic current. The case is related by Dr. Gowers, in his paper upon "Athetosis and post-hemipletic disorders of move-

ment."* The recovery of the patient was distinctly due to the use of electricity, as no other treatment was employed at the time, while other remedies had been previously administered without benefit. The hand of the patient was in constant involuntary movement of irregular extension and flexion, and he was quite unable to pick up a small object. The positive pole of a current, sufficiently powerful to be distinctly but not painfully felt, was held to the back of the neck, and the negative pole for a few minutes upon each of the over-acting muscles. Both conductors stationary. The entire application occupied about fifteen minutes, and was made daily. After each the hand was steadier, and in a week the spasm was considerably less. The patient could then keep his hand flexed or extended, and could manage, although with difficulty, to pick up even a very small object. The applications of electricity were continued during the next two months, the involuntary movements became slighter and slighter, and finally ceased altogether. A little stiffness in the movements of the fingers was all that remained. Dr. Gowers states that, in some other cases in which he has employed the same treatment, marked improvement has taken place, in one case the result being to restore a large amount of use to a limb from

Athetosis.

* *Medico-Chirurgical Transactions*, vol. lix. p. 292.

Athetosis.

which it had been long absent, while, in a case of ataxy, it so steadied the patient's hand (left) as to enable him, a draughtsman, to keep the paper steady on which he was drawing, and so to earn his living.

Tonic Contractions.

In long-standing cases also of tonic contractions of muscles, such as sometimes accompany muscular rheumatism, excitation of the antagonists of the affected muscles proves highly successful. Duchenne reports numerous cases. In one of these, in which contraction of the rhomboid had existed for some years, faradization of the radiating fibres of the serratus magnus, its antagonist, was quite successful. Fig. 89 represents the case before, and fig. 90 after treatment. The patient was a girl thirteen years of age. The affection commenced with pain in the centre and right side of the neck, heightened by pressure, or by movement of the head. This was followed by contraction of the muscles, which increased for four years. When Duchenne first saw her, her condition was as follows. The arms hanging at rest, the inferior angle (D, fig. 89) of the right scapula was drawn up until it was almost on a level with the external angle, and caused a marked projection. To bring it down into its normal position, required the exertion of considerable strength, and the moment it was released it sprang back with an audible crack. Beneath the spinal border of the scapula, which occupied an

Contraction of Rhomboid.

oblique position from within outwards, was a considerable swelling, B, the retracted rhomboid. A

Contraction of Rhomboid.

Fig. 89.*



Before Treatment.

Fig. 90.



After Treatment.

second swelling over the right shoulder was caused by the internal angle of the scapula, which could be distinctly felt under the skin, and to the prominence, A, of the levator scapulæ. Finally, the head was slightly bowed to the right, and an attempt to incline it to the left caused pain. Duchenne produced during the passage of the current a precisely

* A. The levator scapulæ. B. The retracted rhomboid. C. Fibres of the serratus magnus. D. Abnormal position of the inferior angle of the scapula. E. The inferior angle on the healthy side.

Contraction of Rhomboid.

analogous deformity in a healthy person by faradization of the rhomboid and levator anguli scapulæ. To bring down the inferior angle, D, to the level of that of the sound side, the radiating fasciculi of the serratus magnus were faradized; the scapula resumed its normal position, and the swelling, B, disappeared. The sitting lasted ten minutes, but at the end of it the deformity returned. This treatment carried out three times a week for a month produced not the slightest improvement, but to avoid pain to the child the current had been interrupted only once or twice in a second. A very quickly interrupted current, causing great pain, was now used. In four or five minutes there was a sensible improvement; the inferior angle resumed its abnormal position less readily, and remained slightly lower than before. The improvement was maintained the next day, and in a few more applications all deformity disappeared, and the bone retook its natural position.

The above case is an example of the occasional necessity of very painful electrization.

Reflex Contraction.

There is a sort of reflex contraction which sometimes follows upon contusion of an articulation, as of the wrist from falls upon the back or palm of the hand, and which usually appears after the local inflammation has subsided, affects a number of the muscles about the joint, and at length may extend to other joints of the limb. The pain, limited at

first to the muscles first affected, soon extends to others, to the nerve trunks, and finally to their origin in the brachial plexus. Here again painful faradization of the antagonists of the painful muscles has, in Duchenne's hands, been most successful. Reflex Contraction.

Duchenne quotes cases of successful treatment of diphtheritic paralysis by faradization. In one the patient appeared to have contracted membranous angina by kissing the mouth of one of his children who died from the disease. After having passed through the period of the formation of false membranes, which put his life in danger by obstructing the bronchi, and when making progress towards convalescence, he was attacked by paralytic symptoms. There was paralysis of the soft palate and pharynx, diplopia, and slight hemiplegia of the fifth, seventh, hypoglossal, and inferior laryngeal nerves. Suddenly, on the twenty-eighth day, the individual expiratory muscles became paralysed, and at the same time there was formed a considerable quantity of mucus, which obstructing the bronchi, and not being expelled, threatened to produce asphyxia. Electro-cutaneous excitation of the posterior region of the thorax rapidly re-established the respiratory power and procured the immediate expulsion of the bronchial mucus, but it required to be continued for several days in order completely to overcome the paralysis. Diphtheritic Paralysis.

Diphtheritic Paralysis.

In another instance, a little girl four months old, who had suffered from diarrhœa for several days, became the subject of a rather large ulceration in the neighbourhood of the umbilicus. Some days later she was attacked by general paralysis, which continued for forty-eight hours, and was followed by complete aphonia, with extreme difficulty of respiration and deglutition. Every attempt at sucking brought on cough and choking, and there were also symptoms of paralysis of the diaphragm. Faradization of the phrenic nerves was entirely successful in establishing normal respiration. After faradization of the soft palate, the pharynx, and the anterior surface of the neck at the laryngeal level, the infant sucked better and its voice improved. It was completely cured by a few applications.

Difficulty of Micturition.

Difficulty of micturition may in many paraplegic cases be largely relieved by faradization. It is not always symptomatic of paralysis of the bladder, but may be the result of paralysis of the abdominal muscles, and be removed by their faradization. Failing this, the rectal rheophore should be introduced, as described at page 100, and a well wetted sponge connected with the second pole promenaded over the hypogastric or lumbo-sacral region; or the double vesical rheophore may be employed. The continuous voltaic current will often relieve vesical spasm, and has been successfully employed in

painful spasmodic contraction of the bladder upon a calculus. Lesser degrees of spasm will often give way to cutaneous faradization of the perineum or hypogastric region. Anæsthesia of the bladder sometimes exists independently of any paralysis. The patient feels no desire to micturate, the bladder fills, and if not emptied at regular intervals ends by becoming paralysed from the constant distension. Internal faradization with the double vesical rheophore is superior to any other treatment. The dribbling of urine, which is so troublesome in some paraplegic cases, may be frequently relieved, and the condition of the sufferer made much more tolerable. The interrupted voltaic current (where faradization fails) should always be given a trial—one pole to the lumbar spine, and the other to the pubes; length of application about five minutes; interruptions three or four times a minute; application twice daily.

Difficulty of Micturition.

Cases of incontinence of urine in children which have resisted every sort of treatment are on record as having frequently recovered under faradization. One sponge should be applied over the symphisis pubis, and the other to the sacrum and perineum alternately. If this application fails the rectal conductor may be introduced into the rectum and the urethral into the bladder. The current should be as strong as can be borne without pain, and it should pass for about five minutes.

Incontinence of Urine in Children.

Muscular Rheumatism.

The pains of muscular rheumatism are almost invariably removed or mitigated by cutaneous faradization, and so rapidly as in many cases to appear marvellous. In cases that had resisted all other treatment, an instantaneous cure has resulted, and sufferers whose pain has for a long time obliged them to keep the arm immovable have been able directly after the faradization to execute any movement with ease. With these rheumatic patients it is especially of importance that the current should be strictly limited to the skin, carefully dried and powdered, and should *produce no muscular contraction*, or the suffering will be aggravated instead of relieved. Begin with a current readily bearable on your own hand, and increase afterwards. The above remarks are applicable to all varieties of muscular rheumatism, but not to arthritic disease.

Rheumatic Gout.

The voltaic current has been found of the greatest use by Dr. Althaus in the treatment of rheumatic gout. The positive pole should be directed to the cervical spine and the negative to the pit of the stomach, the sponges being of large size and a mild current allowed to flow for from three to five minutes. This frequently causes sleep. Pain may be relieved by a small conductor from the positive pole to the painful spot, the negative with a large sponge being held in the neighbourhood. Length of application, one to five minutes. Dr. Poore has recorded a very successful result from the use of

localized galvanization. The disease had existed for three months, but the severity of the pain had much diminished, excepting towards evening, when exacerbations occurred. The wrist was considerably swollen, and absolutely stiff, the hand pronated and could not be supinated, and the hand and fingers were immensely swollen, so as completely to obscure their anatomy, while the fingers were extended, stiff, pale, and cold, and the nutrition of the entire limb impaired. The whole limb, and especially the hand, was thoroughly sponged with the negative pole, the positive being held in the patient's other hand. After the third application the swelling rapidly subsided, and in about a fortnight the hand, although still stiff, had resumed its natural aspect. The muscles were then faradized and shampooed.* Rheumatic Gout.

Rheumatic arthritis with nodosities is best treated by passing as strong a voltaic current as the patient will submit to through each swollen joint for a few minutes, the direction of the current being frequently changed by the movement of the commutator of the poles. Rheumatic Arthritis.

In all cases of chloroform narcosis, faradization of the phrenic nerves, as detailed at page 80, is of the first importance, but if unsuccessful, recourse should, without loss of time, be had to cutaneous Electricity in Chloroform Narcosis.

* *Op. cit.* p. 145.

Electricity in Chloroform Narcosis.

faradization of the precordial region. The instrument being at its full power and with rapid intermissions, the wire brush is to be brushed over the left nipple, and a disk conductor connected with the other pole moved about over the apex of the heart. Duchenne speaks highly of this precordial cutaneous excitation (which he believes to react upon those points of the nervous centres which govern the innervation of the breathing and of the heart's action), in disorders of the cardiac circulation symptomatic of a paralytic condition of the vagus, causing syncope, which is sometimes fatal. He quotes an interesting case of diphtheritic poisoning of the vagus, and consequent extreme rapidity, smallness, and irregularity of the pulse, with syncope. Diffusible stimulants failed to give relief. The symptoms were removed as if from enchantment by cutaneous faradization; and if the conductors were moved to other parts of the chest, the patient experienced no benefit, and quickly pointed to the region to which the electricity should be applied. There are also other functional disorders of innervation which are much ameliorated by similar treatment—particularly a kind of apnœa, a neurosis characterized by absence of the *besoin de respirer*, and which for a certain time renders the respiratory movements infrequent, and even suspends them.

Disorders of Cardiac Circulation.

Functional Disorders of Innervation.

Impotence.

Impotence is not unfrequently found to be

accompanied by anæsthesia of the genitals, and to be removed by cutaneous faradization. In those cases in which it is due to seminal emissions, and prior treatment has been of no avail, faradization should be given a trial. Introduce the urethral rheophore to the veru montanum, and apply a second rheophore (a well-wetted sponge in a cylinder) to the perineum. Use a low power, and with the pedal rheotome regulate the intermissions at about the rate of two to a second. When the emissions are better, pass a mild and slowly intermitting current through the testicles, applying a well-wetted conductor on each side of them. In those cases in which hyperæsthesia or premature ejaculations exist, the voltaic current should be passed from the lumbar spine to the perineum, and then from the perineum to the glans; both poles stationary; number of cells short of pain; time five to ten minutes. In cases depending upon weakness of the erector muscles, the current should be carefully localized in the bulbo-cavernous and ischio-cavernous muscles. In functional cases, the interrupted voltaic current to the lumbar spine will often be of benefit—positive pole to mid-dorsal region; negative well painted over lumbar twice daily for ten minutes upon getting up and going to bed. This treatment was adopted in the case of a gentleman fifty years of age, who consulted me for gradual decrease of sexual power, ending in

Impotence.

Impotence. complete impotence. Six weeks' treatment resulted, the patient informed me, in the complete re-
Constipation. storation of the normal function. Obstinate constipation frequently results from weakness and relaxation of the abdominal muscles; and in such cases it is often relieved by faradization. When it results from paralysis of the rectum, act directly
Intussusception. upon it as described at page 100. In intussusception introduce the rectal rheophore, and apply about once in a second (regulated by the pedal rheotome) an intense faradic current upon each point of the abdominal walls. Several successful cases that had resisted all prior treatment are on record. Althaus has reported two cases of intussusception cured by faradism, after failure of ordinary treatment. One pole was held stationary upon the spine, and the other promenaded over the surface of the abdomen in the lines of the great intestines. In three minutes the bowels were freely opened in the one case, and in the other where the patient, who had passed much blood at stool, was becoming rapidly exhausted, a copious evacuation took place four hours after the faradization, which had been
Prolapsus Ani. applied for ten minutes. Prolapsus ani from atony of the sphincter may not unfrequently be removed by faradization.

Epilepsy. Remak and Althaus both quote cases of epilepsy which, after other remedies had failed, were cured by galvanization of the sympathetic and brain.

Remak believed that, in successful cases, exudations were absorbed, the application causing a dilatation of the blood vessels of the base of the brain. Epilepsy.

Electricity is coming into use in insanity, and is without doubt a valuable adjunct to the resources of the psychologist. Faradism, and especially cutaneous irritation, with the wire brush would seem to be most suitable for cases accompanied by depression or torpor, the stimulating effects being of service in inspiriting the patient, while the soothing influence of a direct application of the *constant* voltaic current to the brain and cord, may be employed in cases of over-excitement requiring a sedative. Insanity.

In diseases of the skin, some remarkable cases of the cure of eczema, prurigo, and acne have been reported by Beard and Rockwell, as having resulted from central galvanization alone, without any application having been made to the diseased surface; and they consider that their success demonstrates, in an interesting and suggestive manner, the dependence of certain diseases of the skin on the nervous system. In other cases, good results were obtained by localized voltaization, and by faradization, both with sponges and the wire brush. Pain and itching were relieved in all cases, and in some, even of ten years' standing, complete cure was obtained. Prurigo and eczema were most frequently benefitted, one case of eczema, of six years' duration, and in Diseases of the Skin.

Diseases of the Skin.

which the itching was intense, being nearly cured after fifteen sittings. In two cases of herpes frontalis, treated by localized voltaization, the relief of pain was immediate, and the cure rapid and permanent; and similar treatment was remarkably beneficial in a case of elephantiasis, attended with ulceration and great pain. The pain was relieved, and after two months' treatment, the leg was reduced in circumference from twenty-five to seventeen inches.*

* *Op. cit.* p. 572.

CHAPTER V.

ELECTRICITY IN SURGERY.

Surgical Applications of Electricity.

SURGERY, no less than Medicine, owes much to Electricity, for in addition to its indebtedness for the galvanic cautery, the removal and dispersion of tumours by the chemical action of electricity is making daily progress, and will probably before long become a recognised part of ordinary therapeutics. Cases have been recorded by Meyer and others of the disappearance of tumours under external electrization, but in such cases the treatment has been very protracted;* and it is now the almost invariable practice when taking advantage of this disintegrating influence of electricity to introduce one or more needles into the tumour and to connect them with a voltaic battery in action, thus bringing the diseased mass under the direct in-

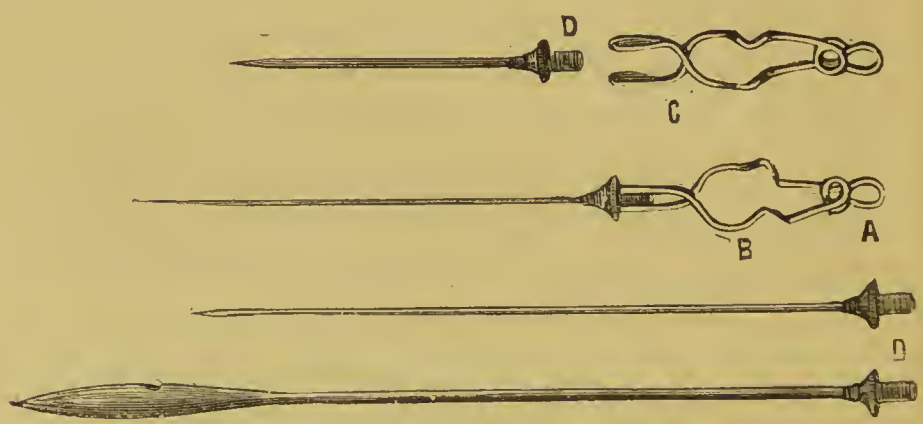
* The best method of applying external voltaization to tumours is to mould a very thin sheet of copper, hardly thicker than paper, to the entire surface of the tumour, to cover this copper with a flannel, and to fix it by a binding screw to the conductor from the negative pole of the battery. Before use, soak the flannel well in a saturated solution of salt in water, and when applied to the tumour, place the positive pole with a well-wetted sponge as near as possible to it, and allow a current as strong as the patient can bear without pain to pass for from twenty minutes to an hour daily, or every second day.

Details of Application in Electrolysis.

fluence of the current. Electrolysis is chiefly applicable to tumours which from their nature or situation are difficult or impossible to be removed by the knife, and perhaps also to malignant tumours; for whether or not the voltaic current exerts a special destructive influence upon disease germs, it seems certainly proved that there is a less frequent return of cancerous growths removed by electrolysis than by the ordinary operative procedures or by caustics.

The most generally useful needles are delineated in fig. 91. I have designed the holder, B, to get

FIG. 91.



Electrolysis Needles and Needle Holders.

rid of the nuisance of special conducting cords. One end of a length of the insulated wire (see page 59) should be twisted into the eyelet-hole, A, and the other end attached to one terminal of the battery, or where several needles being in use it is desired to connect them all with this terminal, the

free ends of their wires may be twisted together, to form a cord for this purpose. In short, the operator furnished with a coil of wire and a pocket-knife can in a few minutes fit up his needles in the manner best adapted to the operation proposed. By pressing the spring sides, B, of the holder, it opens as shown at C, to grasp the screw end, D, of the needle, which should have been previously inserted into the tumour.

Electrolysis. Details of Application.

Nævi and vascular tumours, if of small size, may generally be cured without a scar of importance, if the needle, insulated by gum-elastic or vulcanite to within a quarter of an inch of its point, be carefully introduced, and there is no hæmorrhage. The number of needles must of course vary with the size of the nævus; for very small nævi one needle is sufficient, but for one of, say an inch in breadth, two or three needles will be required. A current of moderate tension, from about eight to twelve cells of my battery, should be allowed to pass until the tumour grows hard and prominent, or shrivels up, and the time required will vary from five to fifteen minutes. Absorption will usually be stimulated at once, and the tumour will entirely disappear in from one to three months. Local anæsthesia will be required, and this may often be sufficiently produced by well painting the part with a mixture of one part of carbolic acid to two parts of sulphuric ether, which is, I believe, the mixture used by dentists. The

Electrolysis in Nævi.

Electrolysis in Vascular Tumours.

pain and the *fear* of the operation will thus be reduced to a minimum. If one needle only is inserted it is better to connect it with the positive pole, as the clot formed at this pole, though small, is hard and firm. A sponge from the other pole may be applied in the neighbourhood of the tumour. If two needles are used one should be connected with each pole, and it is often better in the larger nævi to take out and reinsert these two needles at different stages of the operation, rather than to insert a greater number of needles than two. I need hardly say that insulation of the needles is only required in wholly subcutaneous tumours where we desire to produce coagulation without injury to the skin, and that in all other cases it is a disadvantage rather than an advantage.

Electrolysis in Malignant Disease.

The treatment of malignant tumours by electrolysis is yet *sub judice*, but the evidence in its favour has recently accumulated, and a full and exhaustive trial of this method of treatment by competent observers possessing the opportunities of large hospital practice ought not to be much longer delayed. Neftel of New York is its chief advocate. He contends that malignant tumours are at first entirely local, and he explains their recurrence after removal by the knife from the fact of the impossibility of the whole of the diseased mass being excised, as apparently healthy parts, when microscopically examined, show that they have already become infected. Electro-

lysis, he contends, acts not only on the tumour but also on the surrounding tissues, the current being diffused to some distance in all directions. The cancers most suitable for operation are those that have increased but slowly, and are never very large, those in mammary tumours, for example, that involve but a limited portion of the breast, and in which the skin is not tense but soft, yielding, and of natural colour. Neftel inserts quickly two to four needles, and connects them with the negative pole, while a large sponge from the positive pole is applied to various spots upon the sound skin near to the tumour. Commencing with the current from one cell, the strength is gradually increased until thirty to forty cells are in circuit, and for a time varying from fifteen to thirty minutes. This operation will usually require to be repeated three or four times, and a gentle and not painful current must be applied daily to the *locus morbi* for from a quarter to half an hour, and be continued for some months. Neftel considers this of the greatest importance. In one of his cases, a mammary tumour existed of the size of a small orange. Three needles from the negative pole of thirty cells were inserted for half an hour under chloroform, and the operation was repeated thrice at intervals of a week, daily external galvanization being also used. The tumour gradually became smaller, and at last disappeared, but external treatment was continued

Electrolysis in Malignant Disease.

Electrolysis in Malignant Disease.

for several months, and at the end of a year there had been no relapse. In another case, in which a tumour had been excised by Marion Sims, the disease reappeared, and was again removed by the same surgeon and pronounced cancerous. It a third time reappeared, and was then electrolysed upon three occasions by two, three, and four needles respectively, and with a current gradually increased from ten to thirty cells. The tumour by degrees grew less, and in three months had entirely disappeared, while, when the patient died from another disease some years afterwards, there had been no recurrence.

In one case of scirrhus of the left breast, in which the main portion of the tumour was the size of an orange, and a number of cancerous nodules extended to the axilla, Beard and Rockwell submitted the patient, who was an inmate of the Bellevue Hospital, to the following treatment:—Ether having been administered, three needles were deeply introduced into the tumour, and a fourth into the largest of the axillary nodules. They were all connected with the negative pole, while a large sponge from the positive pole was held applied to the under portion of the gland. The pain, which had been agonizing before the operation, was at once relieved, the tumour began to decrease in size, and in one week had lost more than half its bulk, while the axillary enlargements

had disappeared. The relief of pain in this case was most striking, and even external galvanization would seem to sometimes exert an almost magical influence over the throbbing pains of scirrhus, especially of the female breast. Electrical treatment in a case of epithelial cancer of the rectum and vagina, in which sedatives were powerless, was strikingly beneficial in this respect. An insulated rectal electrode was introduced and connected with the negative pole, while the positive pole, a wet cloth, was gently passed over the very sensitive surface of the tumour. The patient was relieved of pain for a whole night, an occurrence which had not happened for many months before.

Electrolysis in Malignant Disease.

Beard and Rockwell are of opinion that while ordinary electrolysis will cause a reduction in the size of malignant tumours, it will generally, unless in small tumours, fail in radically curing them; and they give the preference to what they term "electrolysis of the base," in which they insert a needle underneath, and, if possible, at some distance below the base of the tumour; and if this is not of large size they so introduce the needle that its point emerges on the opposite side of the tumour. This needle is connected with the negative pole, and a second needle from the positive pole is inserted into the body of the tumour, but near to its base. Commencing with a few cells, the current is gradually increased until electrolysis becomes

Electrolysis in Malignant Disease.

active, as indicated by the yellowish foam appearing at the negative pole and gradually loosening the needle, which, as this action increases, is slowly worked from side to side with a slight cutting motion, so as to undermine the tumour. The positive needle remains *in situ*, and is not removed until the close of the operation. The wound resulting from removal of the tumour is then thoroughly electrized by an instrument termed a "Harrow Electrode," consisting of about twenty points, projecting from a metal plate an inch and a half long by one inch wide; and the authors attach as much importance to the thoroughness with which this part of the operation is performed, and the disease germs as they contend destroyed, as does Neftel to his subsequent thorough elcctrizations of the neighbourhood of the tumour. If future experience should demonstrate that localization of the galvanic current exerts a more powerful destroying or retarding influence upon disease germs than local treatment by caustics, a much more hopeful future will be afforded to the sufferers from malignant disease.

Electrolysis in Aneurisms.

Electrolysis has been employed with success in several cases of aneurism. Where pressure and ligature admit of application, it is hardly necessary to say that the preference should be given to them, but many internal aneurisms, and especially aortic aneurisms, cannot be thus treated, and in such

cases the question of electro-puncture must be carefully considered, and in a suitable case the operation should not be too long delayed. Fine and sharp needles carefully insulated to within a quarter of an inch of their points should be employed. Two needles, one in connection with each pole, should be inserted into the sac of the aneurism. Dr. Poore considers that the elements of the battery cannot be of too small a surface, and he advises that a Foveaux's battery should be employed, so constructed that the tips only of the plates may be inserted into the acid, thus reducing the pain and risk of the operation to a minimum. The current may be allowed to pass for from half an hour to an hour, the number of cells ranging from fifteen to thirty, and the needles should be then carefully withdrawn, and their punctures covered with a bit of cotton, well soaked in collodion or styptic colloid. Some form of local anæsthesia will generally be necessary. Authorities are divided as to the kinds of aneurisms calculated for electro-puncture, but there seems no doubt that an aneurism pressing on the parietes but not having actually perforated them, is the best adapted for this treatment, and that it is contra-indicated where large trunks issue from the sac, and where this is of large size.

Electrolysis in Aneurisms.

The Galvanic Cautery is an application to surgery of the power possessed by the voltaic current of raising a conducting wire to a red or white heat.

The Galvanic Cautery.

The Galvanic Cautery.

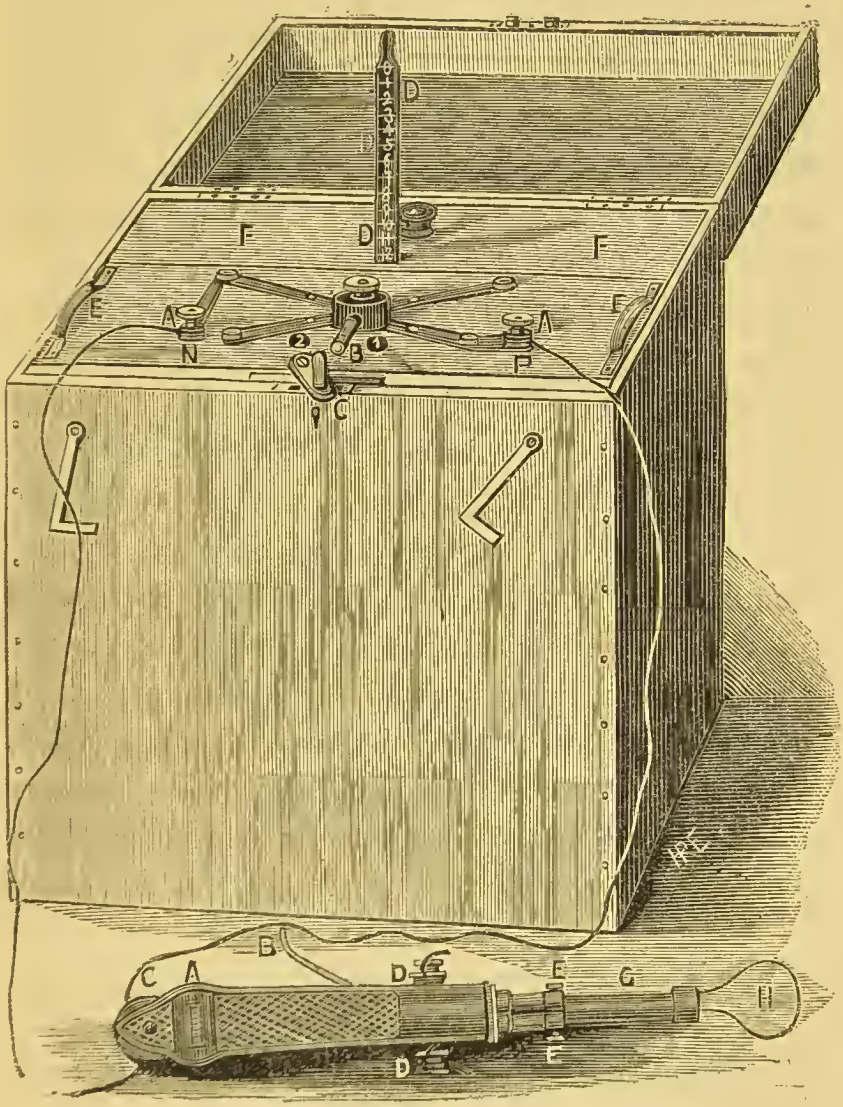
For this purpose ordinary medical batteries are altogether useless, special batteries possessing elements of large surface being required. My investigations into the best method of constructing medical batteries have almost of necessity drawn my attention to those employed in surgery and to what I believe to be their faults of construction, and I have endeavoured to remedy these and to design for the surgeon a battery more manageable and convenient than any other with which I am acquainted.

Hospital Galvano-Caustic Battery.

The Tibbits Hospital Galvano-Caustic Battery, fig. 92, consists of plates of platinum and zinc, which when in use project into cells of vulcanite so arranged that they can be moved vertically up and down, and fixed in any position by a revolving screw movement. The exciting fluid, which fills the lower third of the cells, can be thus brought into contact with the whole or with part of the surface of the elements, or be excluded from them altogether; and the degree to which the elements are immersed in this fluid affords an exact method of regulating the strength of the current. A graduated stem, divided into twelve degrees, rises above the surface of the element board as the cells are lifted up, and enables the operator to read off at a glance the heating power, and to regulate it to a nicety. In the figure the battery is seen at its greatest power, the index standing at "12."

Fig. 92.

Hospital Galvano-Caustic Battery.



Galvano-Caustic Battery and Instrument Holder.*

* A, A. Binding screws for attachment of conducting cords. The letters P and N mark the poles.

B. Lever for varying area of elements.

C. Revolving screw for lifting or lowering the cells.

D. Graduating index.

Hospital Galvano-Caustic Battery.

When out of action it would stand at "0," on a level with the surface of the element board. This is, I believe, the first Galvano-Caustic Battery that has been constructed with any mechanism for the *exact* graduation of its power; and the elements are also so connected that by turning to the right or left the handle, B, of a lever (to "1" or "2" in the figure) they can be employed either as one large or two smaller sized elements. Should it be required to carry the instrument any considerable distance while charged with fluid, the slab, F, should be lifted off, and replaced by the element board and elements, lifted into their new position by the handles, E, E. Vulcanite stoppers, not seen in the figure, are then fitted to the cells, and the cover, F, placed over them in the position occupied in the figure by the element board. The instrument can then be carried without danger of splashing and spilling of a corrosive fluid. For ordinary use the usual formidable array

E, E. Handles for lifting out element board and elements.

F, F. Cover of compartment for the reception of the elements when removed from the cells.

The instrument holder is shown attached to the battery wires. Its parts are—

A. Screw wheel regulating position of binding screws, D, D.

B. Handle for shutting the current "on" or "off."

C, C. Binding screws for cords from battery.

D, D. Screws for terminal ends of the wire loop.

E, E. Screw sockets for reception of different instruments.

G. Insulator.

H. Loop of platinum wire forming the écraseur.

of instruments and fittings is quite unnecessary. A convenient form of holder is required, such as is seen in fig. 92 (with a side view in fig. 93), to be attached by the binding screws, C, C, to the conducting cords from the two terminals of the battery. In the figure it is about to be used

Hospita Galvano-Caustic Battery.

Fig. 93.



Fig. 94.



Fig. 95.



Instruments for the Galvanic Cautery.*

as an Écraseur, a loop, H, having been formed by passing the two ends of a length of platinum wire through the insulator, G, and the canulæ, E, E, to the binding screws, D, D, which by a mechanism controlled by the screw wheel, A, can be made to traverse the entire length of the holder in either direction, thus increasing the size of the loop, H, or

* A. Screw wheel. B. Stop. C. Screws for battery cords. D. Screw for écraseur wire. E. Screw socket. F. Central screw regulating position of binding screw, D. I. Platinum "knife." J. Cautery. K. Adapter. L. Screw holding knife. M. Legs fitting in the socket, E.

Hospital Galvano-Caustic Battery.

gradually lessening it until it is quite drawn within the adapter, G, causing it in its progress to cut through any part previously embraced by it. The current is shut "on" or "off" by the stop, B. The other essential accessories are an adapter, K, (fig. 94,) fitting by its feet, M, into the sockets, E, E, of the holder; a cauterizer, J, (fig. 95,) consisting of a porcelain cone supporting a coil of platinum wire, and fitting through the binding screw, L, to the terminal end of the adapter, K, and a "knife," I, (fig. 94,) a strip of sheet platinum also fitting the adapter, and seen in the figure *in situ*. If the operator wishes other instruments he should have them constructed to fit into the general holder.

Portable Galvano-Caustic Battery.

A similar, but more portable form of battery, is also constructed, which although not so powerful as my hospital battery, is extremely convenient for use in private practice, and which, when freshly charged, gives all the heat that can possibly be required for any one operation; but in Galvano-Caustic Batteries the greatest power cannot be united with extreme portability. The chemical action being very active, it is more important even than in medical batteries that all connections should be kept scrupulously clean with emery or plate powder, the zinc plates, which unscrew to admit of removal, being well amalgamated according to the directions given at p. 26; that the battery should not be placed in action a moment before it is

required; that it should be put out of action directly the operation is finished, and that it should be rested, when permissible, in protracted operations by occasionally lowering the cells. The proper degree of heat to be maintained in the wire of the Écraseur is a blood-red heat, for if the wire is raised to a white heat it is liable to break, or may even be melted. Before commencing his operation, the surgeon should carefully overhaul his battery and instruments, and satisfy himself that they are in good order, and that there is no break in their electrical conduction. If his operation is a large and important one, fresh fluid should be used. Details of Application.

The Galvanic Écraseur is chiefly applicable in operations where the knife cannot be readily used, and in those especially where hæmorrhage should be avoided. It is thus useful in the removal of tumours of the posterior nares, larynx, œsophagus, vagina, and uterus, and in such amputations as those of the tongue and penis. For details of special operations, the writings of Bryant, Marshall, and Erichsen in this country, and Byrne in America, may be profitably consulted. Each operation must of course be planned and performed according to the general principles of surgery, the special cautions as to the electrical part of the matter being that the loop should be accurately adjusted before the electricity is allowed to pass; Galvano-Caustic Operations.

Galvano-Caustic Operations.

that the process of screwing the loop home should be *very* slowly performed, pausing also at intervals in order to give time for the cauterization to control hæmorrhage, and that as the loop becomes smaller the strength of the current should be proportionately reduced so as not to allow the shortened wire to rise above the proper degree of heat. The subsequent pain is much less than after operations by the knife, as the extremities of the nerves are destroyed, and the occlusion of the arteries, veins, and lymphatics would seem also to secure protection from pyæmia.

Advantages over Actual Cautery.

The Galvanic Cautery possesses many advantages over the actual cautery. It can be applied *anywhere;* it can be introduced cold into cavities, and placed in position without injury to the surrounding tissues, which is not always possible with the actual cautery, and it can then be either instantly or gradually raised to any required degree of heat, at which it may be maintained for as long a time as may be desired; and lastly, the pain, and as certainly the *dread*, of the patient are reduced to a minimum.

CHAPTER VI.

ELECTRICITY IN MIDWIFERY AND THE DISEASES OF WOMEN.

Electricity in Midwifery.

The obstetric physician possesses in electricity an agent that, *thoroughly localised in the uterus, will always produce the contraction of this organ, unless its musculur tissue has degenerated;* and it is remarkable that its use in this country should have made such little progress. The fact is thoroughly established that both striped and unstriped muscular tissue will respond by contracting during life, and for a limited time even after death, to the application of one or other of the two forms of electricity—to faradism, or to the interrupted voltaic current; and I have no hesitation in affirming that in those reported cases in which the application of electricity to the uterus is said to have failed in producing contraction, that the electricity has either never reached the uterus AT ALL, or it has been of insufficient power. Failure in localising electricity in an organ withdrawn from sight, and covered with thick muscular tissues, is especially liable to occur, unless the details of application are conducted with extreme care. Assume the case to be an example of severe post-partum hæmorrhage, that

Importance of Care in Application.

Post-partum Hæmorrhage.

the ordinary resources of medicine have failed the obstetrician, and that he fears every moment may be his patient's last, but he has an induction instrument at hand. Let him waste no time, but at once introduce his right hand into the cavity of the uterus, and grasp in his left the moistened sponge attached to one of the conductors of the instrument in action. The current of electricity will pass through his body to the internal surface of the uterus. Let an attendant, holding by its insulating handle the conductor from the other pole (which should be a well-moistened sponge contained in a cylinder (fig. 37, p. 67), thoroughly paint with it, as it were, the abdominal parietes, pressing it with considerable force against the outline of the practitioner's hand, and afterwards apply it to the lumbar region. Contraction of the uterus will invariably result if the current used be of sufficient power. In ordinary cases, where time is not of supreme importance, one or other of the following procedures may be employed. Duchenne's uterine electrode from one pole (fig. 67, p. 102) may be introduced closed into the vagina; and its two plates having been made to separate, should be placed on either side of the os uteri, or an ordinary conductor may be made to touch the os. Two separate conductors from the other pole may be made to grasp the fundus uteri between them through the abdominal parietes which, the

skin being a non-conductor, have been previously well sponged with hot water; or one pole may be held to the sacrum, and the other to the abdomen. Dr. Murray, of New York, states that he has thus treated eighty-two cases of inertia uteri in the second stage of labour, and always with good results. Faradization acts, he says, much more speedily than ergot. Dempsey mentions a case in which labour had persisted for thirty hours, but the pains had ceased for three hours, and the woman was in a condition of alarming prostration. Ergot had been administered in large doses, but without effect. Faradism was then applied for five minutes, and after an interval of five minutes rest for a second five minutes. Powerful uterine contraction then ensued, and after two more applications the labour terminated with the birth of a healthy child. The following is one of Franks' cases:—A woman aborted in the fifth month of her pregnancy in consequence of a fall. The uterine contractions were entirely suspended, and the patient, aroused from a fainting fit by sulphuric ether, was bathed in blood, and looking more dead than alive. The pulse was small, and could not be counted. After the application of faradism for several minutes a strong pain ensued, the uterus contracted, and the bleeding ceased.* Several

Post-partum Hæmorrhage.

Inertia Uteri.

Abortion.

* Quoted in Hammond's translation of Meyer's "Electricity," p. 454. Appleton: New York, 1869.

similar cases have been recorded, as also of the utility of faradism in the production of premature labour.

Induction of Premature Labour.

Berryman quotes a case in which, in a woman with a narrow pelvis, he tried in vain to induce labour by severing the membranes from the uterine walls with the sound. Two days afterwards he introduced into the uterus a flexible male catheter, and allowed it to remain for an hour, but with no better result. The application of faradism produced immediate contraction, and labour resulted.*

The Advantages of Electrization over Ergot.

The advantages of electrization over the administration of ergot, include the rapidity and certainty of its action, the exactness with which its dose can be regulated, and the strength and regularity of the contractions which it produces. It admits also of being used in extreme cases in which the power of swallowing has been lost, or where everything is rejected from the stomach, while it never exerts in any way—as ergot is said to do occasionally—any injurious effect upon the new-born child. Excellent results have followed the application of

Miscarriages.

faradism in miscarriages, where dangerous bleeding had taken place from incomplete expulsion of the ovum; and also in certain cases of excessive

* Galvanism in Effecting Premature Labour: *Edin. Med. Journal*, December, 1862.

menorrhagia, associated with a flaccid condition of the uterus.

Still-born Children.

In connexion with its applications in midwifery, the employment of electricity in the resuscitation of still-born children calls for a passing notice. A typical case is quoted by Meyer,* of a child who was born apparently dead. The muscles were relaxed, and the skin pale, and there was no circulation in the cord. Labour had been long and tedious, and had been terminated by forceps. The usual means of resuscitation having been fruitlessly tried, the phrenic nerves on both sides were faradized (as described at page 80), with the result of producing a contraction of the diaphragm. Faradization was continued at intervals of every three or four minutes; but it was upwards of half an hour before the first sign of life appeared in the production of an independent inspiration. This was soon repeated, when electricity was discontinued, and revival completed by ordinary cutaneous excitation. In such cases, if the operator does not succeed in excitation of the phrenic nerves, cutaneous faradization with the wire brush should be resorted to.

Electricity as a Galactagogue.

Electricity again may subsequently be of service to the mother, should she suffer from non-secretion of milk, owing to a sluggish condition of the glands, or to mal-nutrition. The mammæ should

* *Op. cit.* p. 457.

Electricity as a Galactagogue.

be faradized with moistened conductors, or their skin acted on by the wire brush. Dr. Skinner has reported in the Obstetrical Transactions for 1864, a case (quoted by Althaus) of a lady who, while nursing her fifth child, suffered complete suppression of milk. After one application of faradism to the left breast, the patient declared that she felt a rush of fluid to it, and in a few hours the normal supply appeared. The right breast had not been used for some years—owing to an old abscess; but it was faradized twice for five minutes, which brought on as much milk as in the other breast. Many other similar cases are on record.

Electricity as an Emmenagogue.

According to Golding Bird, electricity is the only true emmenagogue that we possess. Be this as it may, all of its forms are serviceable in stimulating the secretions, and may be employed with success in cases of suppression of the catamenia from a torpid condition of the uterine organs. A generalized application will often suffice. Let the patient sit with her feet in tepid salt and water, in which is immersed a wire from one of the poles of an induction instrument in action, while a large sponge from the other pole is held applied to the lumbar region. Strength of current as much as she will bear. Time, ten to fifteen minutes. The application should be made twice daily for the three or four days preceding the usual catamenial period. If this method fails in its object, direct electriza-

tion must be resorted to, and Franklinization most often succeeds. A few shocks from a Leyden jar should be passed through the pelvis from the lumbo-sacral region to the pubis at each sitting. By this treatment Golding Bird succeeded in curing twenty out of twenty-four cases of amenorrhœa, the four exceptions being chlorotic girls. But Franklinic instruments are not commonly at hand, and failing them the uterus may be faradized by any of the methods already described, or in unmarried women one pole may be held to the abdominal parietes and the other to the lumbar spine, but this is less certain than localization of the current in the uterus itself. Althaus has found a powerful voltaic current passed from the mons veneris to the lumbar spine, for from fifteen to twenty minutes, more effective than faradization.

Electricity as an Emmenagogue.

Independently of its specific effects, electrization, by improving the nutrition, may be of benefit in atrophy, and, by its tonic effects upon the ligaments and uterine and vaginal walls, and by inducing contraction of the muscular fibres, in displacements of the uterus. Tripier has detailed several cases of uterine disease treated by localized faradization. Of anteflexion and anteversion, four cases recovered and two were improved; of retroversion and retroflexion, one recovered and one was improved. In anteversion or anteflexion, he acts chiefly upon the posterior portion of the uterus by

Uterine Displacements.

Uterine Displacements.

one conductor in the vagina and the second in the rectum; in retroversion and retroflexion, he first raises the fundus uteri by the introduction of an air pessary into the rectum, and then passes a faradic current from the os to a second conductor introduced into the bladder; or, in unmarried women, one electrode in the bladder, and two sponges from the second pole, one applied to each iliac region. Good results were also obtained in chronic metritis.*

Uterine Neuralgia.

In my own hands an intractable case of uterine neuralgia was perfectly cured by the voltaic current; and I have knowledge of a case of sterility which the localization of the voltaic and faradic currents alternately would seem to have removed. One conductor was applied to the os, and two sponges from the second pole—one to the position of each ovary. The applications were made thrice a week for a fortnight before each menstrual period, and for a period of four months. Conception followed, and the patient, who had been married for thirteen years, in due course gave birth to her first child.

Sterility.

Concluding Remarks.

In the foregoing pages I have endeavoured—assuredly not to exhaust my subject—but, eschewing debateable ground, to indicate the prominent

* Tripier, "Annales de l'Electro-therapie," p. 202, *et seq.*

Concluding Remarks.

landmarks in the wide and unexhausted field of electro-therapeutics. My object will have been answered if I have succeeded in clearly describing the different modes of applying electricity, and the apparatus by which the application is best made; also in specifying those cases in which the use of some one or other of the different varieties of electricity is certainly demanded; and those cases again where—other remedies having been tried and failed—we may hopefully resort to this agent, and in which it were surely a neglect of duty to let the disease run on without giving the patient the opportunity of its thorough trial.

In conclusion, I would state that the medical practitioner who prescribes electricity should, as a general rule and with few exceptions, either administer it himself or cause it to be administered by a skilled operator. The experience of the National Hospital for the Paralysed and Epileptic, and my own experience in private practice, show conclusively that when patients themselves apply electricity, the result has been most frequently unsatisfactory. The most explicit directions will often be misunderstood, or will be imperfectly carried out, the treatment getting undeserved discredit. The rule of practice here laid down is particularly applicable to the localized application of electricity.

INDEX.

ACCESSORIES of apparatus, 59
Adams, Mr., on infantile paralysis, 157
Advantages of galvanic over actual cautery, 238
Althaus, Dr., on cerebral electrization, 173
Amaurosis, 198
Anæsthesia, *note* to page 202
Anelectrotonus, 116
Anstie, Dr., cases of neuralgia, 135
Application of electricity, 81
Applications of electricity, precautions necessary in, 118
Athetosis, 208
Atrophy, muscular, 183
Auditory nerve, electrization of, 105

BASTIAN, Dr., case of lead palsy, 188
Bath, electro-negative, 63
Bath, electro-positive, 62
Baths, electric, 122
,, ,, in gouty and rheumatic affections, 125
,, ,, in lead poisoning, 124
,, ,, mode of administering, 124
Batteries, fixed, currents from, less irritating, 13
,, fluid, disadvantages of, 13
Battery, faradic, directions for regulating, 34
,, ,, Duchenne's, 36
,, ,, the Tibbits, 31
Battery, Pulvermacher's chain, 28
,, Stöhrer's, 24
,, the Becker-Muirhead, 9
,, the Tibbits combined hospital, 55
,, ,, ,, portable, 57
,, ,, voltaic, 16
,, voltaic, essentials of, 8
,, Weiss's, 21
Beard and Rockwell on electrolysis, 229
Becker-Muirhead battery, 9
Benedikt, case of hemiplegia, 175
Bladder, electrization of, 100
Brain, electrization of, 131

CATELECTROTONUS, 115
Cauterization, electric, 100
Cautions, 118
Cell, the Leclanché, 15
Cells, no absolute rule as to number of, 135
Central galvanization, 121
Cerebral electrization, 175
,, hemispheres, electrization of, 136
Cleanliness, necessity of, in apparatus, 13
Coils, distinction between, 33
Conductors, *see* Rheophores
Constant current, 64, 118
Contraction of muscles from too powerful faradization, 193
,, of rhomboid, 210

Cord, electrization of, 132
Current, constant, 64, 118
„ interrupted, *see* Faradism
„ „ voltaic, 64
Cutaneous faradizatlon, 99

DEAF-MUTISM, 201
Deafness, 200
Diagnosis between real and pretended disease, 112
„ electricity in, 106
„ of lead palsy from paralysis of musculo-spiral nerve, 110
„ of peripheral from central disease, 109
Differential use of voltaism and faradism, 130
Difficulty of micturition, 214
Diphtheritic paralysis, 213
Disorders of cardiac circulation, 218
Duchenne, Dr., case of traumatic paralysis, 146
„ case of hysterical paralysis, 186
„ large covered faradic battery, 36
„ large uncovered faradic battery, 38
„ magneto-faradic battery, 46
„ small faradic battery, 43
„ sponge holders, 67

ELECTRIC baths, 122
Electrical machine, 5
Electricity, application of, 61
„ as proof-positive of death, 112
„ effects of, upon nutrition, 115
„ effects of, upon the secretions, 115
„ general principles of all therapeutic applications of, 117
„ in diagnosis, 106
Electricity in medicine, 114
„ in surgery, 222
„ limitation of, as a remedy, 114
„ precautions necessary in application of, 118
Electrization as a galactagogue, 243
„ as an emmenagogue, 244
„ cerebral, 175
„ direct details of, 69
„ direct muscular, 66
„ indirect, 71
„ in abortion, 241
„ in chloroform narcosis, 217
„ in diseases of the skin, 221
„ in epilepsy, 220
„ in hemiplegia, 170
„ in inertia uteri, 241
„ in insanity, 221
„ in paralysis, 139
„ in post-partum hæmorrhage, 240
„ localized principles of, 61
„ method of, in oculo-motor paralysis, 198
„ of auditory nerve, 105
„ of bladder, 100
„ of brain, 131
„ of cord, 132
„ of crural nerve, 92
„ of facial nerve, 73
„ of internal intercostal nerves, 90
„ of internal organs, 100
„ of larynx, 102
„ of male genital organs, 103
„ of median nerve, 84
„ of motor points of anterior surface of left arm, 83
„ of motor points of anterior surface of left forearm, 86
„ of motor points of anterior surface of left thigh, 93
„ of motor points of inner surface of left leg, 97

Electrization of motor points of outer surface of left leg, 96
,, of motor points of posterior surface of left arm, 87
,, of motor points of posterior surface of left forearm, 88
,, of motor points of posterior surface of left thigh, 94
,, of motor points of surface of trunk, 90
,, of muscles, *see* Muscles
,, of musculo-cutaneous nerve, 84
,, of nerves of taste, 105
,, ,, of the cavity of the mouth, 77
,, ,, to abdominal muscles, 91
,, of obturator nerve, 93
,, of olfactory nerves, 105
,, of sympathetic, 131
,, of ulnar nerve, 85
,, of uterus, 102
,, of the brachial plexus, 82
,, of the central organs of the nervous system, 98
,, of the hypoglossal nerve, 79
,, of the nerve of Willis, 78
,, of the organs of the senses, 104
,, of the peroneal nerve, 95
,, of the phrenic nerves, 80
,, of the retina, 105
,, of the sciatic nerve, 94
,, of the tibial nerve, 95
Electro-contractility, *see* Irritability
Electro-negative bath, 63
Electro-positive bath, 62
Electrodes, *see* Rheophores
Electrolysis, 224
,, in aneurisms, 230
,, in malignant disease, 226
,, in nævi, 225
Electrolysis, needles for, 224
Electrotonus, 115
Epilepsy, 220
Ergot, advantages of electricity over, 242
Essentials of a faradic instrument, 30

FACIAL palsy, case of, 196
Faradic current, how obtained, 32
Faradism, 30
,, and voltaism, differential use of, 130
Faradization, cutaneous, 99
,, general, 120
,, in neuralgia, 132
Franklinism, mode of generating, 5
Franklinization, 62, 124
,, by sparks, 63
,, by the Leyden jar, 63
,, in emotional aphonia, 126
,, in facial spasms, 126
,, in localized excessive sensitiveness, 127
,, in sciatica, 126
,, in tremor, 127
Functional disorders of innervation, 218
Fustigation, electric, 100

GALVANIC cautery, 231
,, ,, instruments for, 235
Galvanism, *see* Voltaism
Galvanization, central, 121
Galvano-caustic operations, 237
Galvanometer, note on the use of, 135
General faradization, 120
,, principles of all therapeutic applications of electricity, 117
Genital organs, electrization of, 103
Glass-legged stool, 5
Glosso-labio-laryngeal paralysis, 202
Gout, 216
Gowers, Dr., case of athetosis, 208
,, ,, paralysis of musculo-spiral nerve 190
,, pedal commutator, 173

HAND, atrophic paralysis of, 166
Hemiplegia, Benedikt's case of, 175
,, case of, 171
,, electrization in, 170
,, late rigidity in, 171
,, Radcliffe's positive charge in, 176
Hospital, National, cases from, 169
Hysterical paralysis, 185

IMPOTENCE, 218
Incontinence of urine, 215
Induced, *see* Faradic
Induction, *see* Faradism
Infantile paralysis, 156
,, case of, 168
Insanity, 221
Instruments, 4
Intussusception, 220
Irritability diminished, 108
,, increased, 108
,, ,, to voltaism, and diminished to faradism, 109
,, in cerebral paralysis, 111
,, in emotional paralysis, 111
,, in infantile paralysis, 112
,, in spinal paralysis, 111
,, in wasting palsy, 112
,, mode of testing, 106
,, normal, 108

KNOTT, Mr. S. J., case of plumbism, 124

LARYNX, electrization of, 102
Lead palsy, 187
Leclanché cell, 15
Leyden jar, Franklinization by, 63
Local paralysis, 187
Localized electrization, principles of, 61
Locomotor ataxy, case of, 202

METALLIC poisons, elimination of, 123
Method of holding rheophores, 67
Midwifery, 239
Miscarriages, 242
Moxa, electric, 100
Muscles, electrization of abductor longus pollicis, 89
,, ,, abductor minimi digiti, 87
,, ,, buccinator, 76
,, ,, first dorsal interosseous, 89
,, ,, frontal, 75
,, ,, latissimus dorsi, 92
,, ,, obliquus externus abdominis, 91
,, ,, opponens pollicis, 87
,, ,, orbicularis oris, 76
,, ,, orbicularis palpebrarum, 74
,, ,, splenius capitis, 92
,, ,, the sterno-mastoid, 79
,, ,, stylo-hyoid and digastric, 74
,, ,, transversalis abdominis, 91
,, ,, zygomatici, 75
Muscular atrophy, 183
Myelitis, voltaic current in, *note* to page 177

NAIL, electric, 99
Needle, vibrating directions for regulating, 34

Neftel, on electrolysis, 226
Nerves, electrization of, *see* Electrization
Neumann, case of wasting palsy, 182
Neuralgia, case of, 137
,, facial Franklinization in, 125
Nomenclature, 3

OLFACTORY nerves, electrization of, 105

PAIN, relief of, 132
Palsy, wasting, 181
Paralysis, atrophic, of hand, 166
,, diphtheritic, 213
,, functional, *note* to p. 139
,, hysterical, 185
,, importance of influence of the will in, 161
,, infantile, 156
,, ,, cases of, 168
,, ,, importance of careful examination in, 160
,, of musculo-spiral nerve, 190
,, of ocular muscles, 197
,, rules for electrization in, 139
,, spinal, 176
,, traumatic, 145, 154
,, voltaism in, 152
Paraplegia, 177
,, case of, 179
Poore, Dr., case of paraplegia, 180
Positive charge, Radcliffe's, 65
Precautions necessary in applications of electricity, 118
Premature labour, 242
Pulvermacher's chain battery, 28
Pye-Smith, Dr., case of amaurosis, 199

RADCLIFFE, Dr., case of neuralgia, 133
,, ,, on infantile paralysis, 167
Radcliffe, Netten, Mr., case of paralysis of deltoid, 141
Radcliffe's, Dr., positive charge, 65, 127
,, ,, in facial palsy, 193
,, ,, in wasting palsy, 181
Rectum, electrization of, 100
Retina, electrization of, 105
Reynolds', Russell, Dr., case of neuralgia, 136
Reophore, Duchenne's vesical, 101
,, laryngeal, 103
,, metallic, with disk, 67
,, olivary metallic, 68
Reophores, conical metallic, 68
,, method of holding, 67
,, solid metallic, 99
,, Ziemssens', 72
Rheumatic gout, 216
,, paralysis, 189
Rheumatism, 216

SKIN diseases, 221
Sparks, franklinization by, 63
Spasmodic affection, case of, 207
Spinal paralysis, 176
Splenius, contraction of, case of, 205
Sponge holders, Duchenne's, 67
Static electricity, *see* Franklinism
Sterility, 246
Still-born children, 243
Stöhrer's battery, 24
,, larger faradic battery, 51
Sturge, Dr., case of facial palsy, 194
,, case of neuralgia, 138
,, cases of muscular atrophy, 185
Sympathetic, electrization of, 131

TASTE, electrization of nerves of, 105
Threads, metallic, 99
Tibbits combined hospital battery, 55
,, ,, portable battery, 57

Tibbits faradic battery, the, 31
,, galvano-caustic battery, the, 232
,, voltaic battery, the, 16
Tinnitus, *note* to, 201
Tonic contractions, 210
Torticollis, 204
,, case of, 206
Tremor, 203

UTERINE displacements, 245
,, neuralgia, 246
Uterus, electrization of, 102

VOLTAIC battery, essentials of, 8
,, ,, Tibbits, 16
Voltaism, 8
,, and faradism, differential use of, 130
Voltaism in myelitis, *note* to, 177
Voltaization, 64

WASTING palsy, 181
,, ,, case of, 182
Watson, Sir Thomas, on paralysis, 140
Weiss's battery, 21
Winter's electrical machine, 7
Women, diseases of, 239
Writer's cramp, 204

ZIEMSSEN, on indirect electrization, 71

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